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Sorghum Newsletter

VOL. 2

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SORGHUM RESEARCH COMMITTEE

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SORGHUM NEWSLETTER

Vol. 2

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W. M. Ross, Editor

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I. INTRODUCTION

One Hundred Years of Sorghum Production in the United States

A. F. Swanson (Hays, Kans.)

Introduction

Sorghum is an emigrant crop which became established in a small way in the United States a little more than 100 years ago. As a grain crop in the United States it is now exceeded in production only by corn, wheat, and oats. Benjamin Franklin is said to have introduced broomcorn between 1729 and 1768. It proved useful to the wives of the colonists for their house brooms. Broomcorn followed the pioneers westward until at the present time it is centered largely in the High Plains of Oklahoma, Texas, New Mexico, Colorado and Kansas. Gyp corn and Giant milo too are said to have filtered into the country by way of South America in the slave ships as subsistence for the unwilling cargo while in transit because it was their natural food in Africa. But these sorghums made no permanent impact in the United States. The more important forage and grain sorghums which is the subject of this discussion followed a different pattern.

Sorghum introductions from foreign sources, 1853 to 1910

During the above period there was a great influx of forage and grain sorghums from widely scattered world sources. In this long period the best of the introductions were sifted out and established. Since 1910 very few foreign introductions have been superior enough in their own rights to compete with the previous groups although some have been useful as sources of new germ plasm. Most of the American varieties have been of African origin.

The forage sorghums, often interchangeably spoken of as the sorgos or the saccharine sorghums because of the sweetness in the stalks, were the first to be established.

The first important sorgo was of Chinese origin from where the seed reached France in 1851, the United States in 1853, and later the Plains as Black Amber. In Kansas Black Amber was the dominant forage variety for more than 50 years. Other regional strains of this introduction prevailed in other areas of the Middle West.

Of great importance was the introduction in May, 1857, of 16 saccharine varieties brought to the United States by Leonard Wray. These were grown first in Georgia and South Carolina. Mr. Wray became interested in these varieties in 1851 while in Natal, South Africa, where they were grown by the Zulu-Kafir tribes for their grain and sweet stalks.

These tall, sweet, and juicy introductions became the basic genetic material for nearly all of the forage varieties now grown in this country and have given rise to such fixed types as Orange, Sumac, Collier, Planter, Gooseneck, Honey, Sapling, Sourless and others, some of which are still grown, as well as those that have come from hybridization.

In the beginning the forage sorghums were used principally as a source of molasses or sugar. From about 1887 to 1890 intensive experiments were under way in Kansas, and processing plants were built to produce table sugar. It was almost a success. A series of low yields followed, the sugar content was low, subsidies were taken off, and the competition with sugar beets could not be met. At the present time under irrigation and improved techniques, satisfactory sugar could readily be made if stress and economic conditions warranted.

As the forage sorghums reached the Plains it was soon learned that the crop had value as roughage for cattle for winter use. It has been said that the forage sorghums, the barbed wire fence and the windmill, later supplemented by wheat and other cereals stabilized the agriculture on the Plains. This caused the decline of the free range after 1885.

The earliest grain sorghums to become established in this country appears to have been Brown Durra and White Durra in California in 1874. During a period of drought, White Durra under the name of Rice corn became popular in Kansas and about the same time reached Texas and other parts of the High Plains.

Strains of kafirs and milos reached the country between 1878 and 1905 that became the foundation sources of the grain industry. Among the notable varieties that arose from selection and mutation were Texas Blackhull, Western Blackhull from Kansas, Dawn and a series of tall and dwarf milos with yellow or white seed. Later came Shallu from India and Feterita from Egypt. In 1905 a mixed lot of kafir seed was received by the U. S. Dept. of Agriculture and given to the Rockefeller Ranch near Russell, Kansas, and then to the Ft. Hays Experiment Station where C. C. Cunningham selected Pink Kafir that for 40 years was widely grown for its high yield.

About the last important grain sorghum introduction was Dwarf Hegari received in 1908 and distributed from Chillicothe, Texas. It has had wide distribution in the Southwest.

The kaoliang group of sorghums from China and Manchuria were received between 1898 and 1910 but never gained a foothold. The kaoliangs were tall and scanty of leaves and were used in the Orient to serve three purposes, the grain for human food, the leaves for the animals, and the dry stalks for fuel or as material for shelter. In all of these categories the yield was low, and the American farmer would have nothing to do with the group. In contrast the varieties from India were tall, very leafy, late as a rule, and unmanageable.

Sudangrass was introduced in 1909 from Khartum, Sudan, Africa, and quickly became firmly established and has since been of immense value to the country as a grass crop. Improved types more free from prussic acid have recently been distributed.

Evaluation and purification of foreign introductions, 1900-1920

This was the period of evaluation, purification, and determination of regions of adaptation of the new crop by a small group of sorghum researchers. The crop spread rapidly over the Great Plains where it had natural adaptation and where it was superior to corn because of greater drought resistance.

It was also a period of cheap hand labor. The attempt was made, therefore, to get varieties of convenient height so that the heads could be harvested easily with a butcher knife and thrown into a wagon in the same manner as husking corn.

The crop was often sold in the unthreshed heads then stored and dried in the fall on the ground in long ricks at the country elevator to await the threshing machine. By 1940 this method of harvesting had become obsolete. Instead loaded trucks of threshed grain from the combines would be lined up for several blocks awaiting a chance to be dumped at the elevator. At the close of the 1900-1920 period mechanism was just around the corner that was to influence greatly the expansion of the crop.

Hybridization and mechanization, 1920-1940

One of the outstanding achievements of this period was the advance made in genetics and inheritance studies of sorghum characters that was to have practical application. Sorghum plant breeding work had already been in progress in India previous to 1920 and the findings were helpful to the American workers. Also up to about 1920 the old introductions or selections therefrom had reached a high state of homozygosity so that the time was ripe to do full scale breeding work with the crop.

Genetically, the factors for plant height and maturity, seed colors, juicy and dry stalks, linkage groups, awns and head size and shape and many other characteristics were determined. Resistance to such troublesome pests as Periconia root rot in all milos, kernel smut, and chinch bugs were incorporated into useful farm varieties with high yield.

Of great importance during this period which radically changed grain sorghum production was the development of the short dwarf combine types in which the internodes of the stalks were telescoped, but with sufficient leaf surface so that the functions of photosynthesis were not impaired. The dwarfs yielded as well as the taller types.

The first dwarfs were not well accepted as the farmers were accustomed to the taller types. Previous to 1920 H. W. Smith a farmer-plant breeder, Garden City, Kansas, had produced a dwarf grain sorghum that could be harvested with a wheat header since suitable combines had not yet been involved. Smith was 25 years ahead of the times.

J. B. Siegliner of the U. S. Dept. of Agriculture at Woodward, Okla., began making crosses in 1919 and by 1931 had produced a number of varieties

of combine height. One of these, named Wheatland, was the first to go into commercial production from the Kansas and Oklahoma stations. This was a turning point in sorghum production. In the next 10 years a number of additional commercial dwarf types were developed by the Texas, Kansas, and other stations.

By this time the combines were reaching perfection, and a new era was opened for the sorghums. Simultaneously with the combines came improved furrow planters, disc weeders, one-way plows, and duckfoot and other tillage implements for the preparation of better seedbeds. Wheat drills with wider row spacing were well adapted for surface planting the grain sorghums on pre-tilled seedbeds. This made possible the use of the same machinery for the production of both wheat and grain sorghum.

Advances of sorghum genetics, utilization and production, 1940-1958

This period was the most fruitful in all of the 100 years that the crop has been grown in this country. Without doubt the greatest revolutionary accomplishment in this period was the utilization of cytoplasmic male-sterility for hybrid seed which came into farm use in 1956 and increased the yields from 20 to 30 percent. Sorghum hybrids had long been recognized as a possibility for increasing the yields, but the development was delayed by problems in seed production.

Many years had been spent by the Texas workers in attempting to do this by the use of genetic male-sterility, but the process was somewhat costly and cumbersome to put into practice. The discovery of cytoplasmic male-sterility and the technique for its application changed the situation almost over night. The acreage of grain sorghums planted to hybrid seed, at the present rate, will soon approach the 100 percent mark. The end is not yet seen in the further improvement of more suitable hybrids for standability, seed quality, and greater resistance to insects and diseases. Also the production of hybrid seed is rapidly changing from the small individual grower to a contract basis by large commercial producers. These commercial producers have their own trained staffs, and highly equipped seed processing plants, and sales agencies for the promotion of their business.

World War II greatly stimulated the production of the dwarf combine sorghums which had now been perfected. Combine harvesting definitely was substituted for hand harvesting as the farm boys left for service while the fathers and the older men were left to handle the crop.

During the war large amounts of sorghum grain was converted into alcohol and for use in munitions. Sorghum grain was well adapted for this purpose, but with the close of the war, industrial alcohol could be made cheaper from petroleum and black strap molasses from the sugar industry. A rapid decline of sorghum grain for this purpose soon followed.

During World War II sorghum grain suddenly became important as a source of special and ordinary starches. Earlier the Texas workers had found that

both non-waxy (amylose) and waxy (amylopectin) starches could be obtained from sorghums depending on the variety. Up to the time of World War II most of the waxy starches used for tapioca or adhesives were produced in the Dutch East Indies from the cassava plant. This source was soon cut off by the enemy action of the Japanese. Cody, a sorghum variety developed at the Hays Station, was found to have the waxy grain. From a small supply in 1942, it was quickly increased to more than 8,000 acres in the Texas Panhandle and elsewhere. It supplied an urgent war need. Cody did not have good agronomic characteristics and soon went out of production hastened by waxy starch that had become available from Brazil. In recent years there has again developed a demand for waxy starch from sorghum for special uses. There are also other industrial uses for this special starch that could develop a strong market contingent upon cost and availability. Improved waxy sorghums, such as Texioca-54, are available to meet such demands. Sorghum grain starch is now being made into dextrins and dextrose at Corpus Christi, Texas.

During the period of 1940 to 1958, great developments were made in the use of herbicides and insecticides which were not available in the early years. Improved machinery and tillage practices have been refined and modified for better production of the crop.

Another impressive development is the use and rapid increase in the number of driers in the Great Plains at most country elevators to reduce the moisture content of the grain to 12 percent or lower at the time of the harvest. Without the driers it was often necessary to wait until after frost to combine. If the dry fall did not follow, heavy grain losses often occurred, or the crop went out of condition. This risk now has been alleviated.

The use of driers has made possible the introduction of the grain sorghums into the Corn Belt. The increased acreage in this region has been impressive during the last two or three years. With the return of free acreage in corn production, some decline in sorghum in this region can be expected.

Finally, in the 100 years of sorghum culture, in spite of all that has been accomplished, there still remains much unfinished research to bring this emigrant crop to even greater production, better quality and usage. Fortunately, a new crop of highly trained sorghum researchers have already taken over much of the work of the small but valiant group of older workers who guided the destiny of the sorghums for a century.

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II. CONTRIBUTIONS FROM COOPERATORS

ARIZONA

Lee Stith (Tucson)

Personnel

Our sorghum research program is being divided into a (1) forage section and (2) grain section. The division is being made because a new position was added April 1, 1958, and each person will have a section to develop. Dr. A. A. Baltensperger, from Iowa State College, joined the department April 1, 1958 to work on sorghums but has since transferred to other duties.

Double harvesting grain sorghum

Double harvesting (ratooning) of grain sorghum has been under experimentation at lower elevations in the Southwest. At Yuma, Arizona, where sorghum may successfully be planted in late February or March, this practice may prove satisfactory. At some of the other low elevation areas in the state, double harvesting appears slightly less promising. Double harvest yields shown in table 1 may be compared with the following single harvest yields of RS 610 when planted at the recommended planting dates for one harvest at three locations in 1958: Yuma 3,934, Mesa 2,270 and Marana 5,619 lbs. per acre.

Grain sorghum variety trials

Hybrid grain sorghums were superior to the best varieties at the higher elevations but not at lower elevations in southern Arizona in 1958. D. D. 38, D. D. 38 and Comb. Hegari, and D.D.Y.S. yielded as much or more than the best hybrids at Yuma, Marana and Mesa, respectively. At higher elevations, such as Willcox, Safford and Tucson, some hybrids similar to RS 610 in maturity gave superior yields. Station hybrids RS 610 and Texas 660 are now recommended for this area.

Table 1. Double harvest grain sorghum yields from three locations in 1958.

	Pounds of grain per acre		
	Yuma	Mesa	Marana
RS 610			
First harvest	5,053	3,836	3,140
Second harvest	3,119	3,513	1,598
Annual yield	8,172	7,349	4,738
Amak R-10			
First harvest	5,193	4,506	3,535
Second harvest	2,780	3,764	1,669
Annual yield	7,973	8,270	5,204
Double Dwarf Yellow Sooner			
First harvest	5,229		
Second harvest	4,279		
Annual yield	9,508		
Double Dwarf 38 Milo			
First harvest		3,503	
Second harvest		3,191	
Annual yield		6,694	
RS 501			
First harvest		Lost	2,772
Second harvest		3,433	1,957
Annual yield		3,433	4,729
Planting date	April 11	March 25	April 23
First harvest	July 10	Aug. 9	Aug. 8
Second harvest	Nov. 7	Nov. 21	Dec. 14
Elevation (ft.)	100	1100	2100

Forage test

Forage work has been conducted on a limited scale over the state. A few problems have come to our attention that are probably characteristic of this area only. For example, some of the growers attempt double harvest of forage sorghums. Hegari, and some hybrids when planted early (March), respond to the short day and bloom before the desired vegetative growth is attained. Secondly, some forage varieties and hybrids that perform well under rainfall conditions, grow too rank under irrigation and high fertilizer and lodge badly. No TDN evaluations were made.

The results last year at various locations in the state are:

Table 2. Forage sorghum variety tests, Arizona, 1958.

Variety	Tons green wt/acre			
	Mesa	Safford	Marana	Yuma
Hegari	7.3	10.6	16.9	--
Advance Silage Mix	14.4	17.3	19.9	29.1
Brawley	18.1	--	--	40.7
Tracy	19.9	22.3	28.1	57.7
Atlas	13.4	--	18.7	41.7
Rex	--	16.6	--	20.2
NK 320	--	32.4	28.2	51.3
DeKalb FS-1	--	14.7	14.2	25.5
Tracy-Atlas (50-50)	--	--	--	39.6

Variety (grain) - fertilizer - irrigation study

We feel that these three factors are interrelated and must be studied together here. This study has been followed for three years at Yuma, Arizona, and the 1958 results are typical except for one year (1956). In 1956, the seed set was reduced to 30% where water was not optimum. Seed set was not affected other years. There was no response to fertilizer on the Yuma farm.

Table 3. Sorghum yields under various irrigation and fertilizer treatments, Yuma Experimental Farm, 1957-58.

Variety	Irrigation levels*	
	Optimum	Stress
Early Maturity		
DD Yellow Sooner	2874	2856
RS 501	2626	3527
Medium Maturity		
DD 38	3456	3276
RS 610	3529	3439
Late Maturity		
Texas 660	3323	2895
Hegari	2831	2311
Imperial Kafir	4005	3328

*Optimum irrigated each week, stress irrigated at 3 week intervals.

Field purity studies

In cooperation with the Arizona Crop Improvement Association, an attempt was made to evaluate off-types in hybrid seed. A winter growout was tried in Culiacan, Mexico, in 1957 with the planting date in December. Apparently, day length masked the appearance of the hybrids.

In 1958, plantings were made October 15, November 1, November 15 and December 1 at the same location. Expression of off-types was evident in the October 1 and November 1 plantings.

Disease

Of note is a disease causing stunting of plants, proliferation of stems, and philody of the heads. The Department of Plant Pathology has made isolations from infected plants and associate the pathogen with western cucumber mosaic. The disease until now has been restricted to the Mesa Experiment Farm as far as we know. The yield of infected fields is usually reduced by at least 50%.

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COLORADO

Sorghum Experiments in Colorado

Warren H. Leonard (Ft. Collins), Herbert O. Mann (Springfield),
Floyd W. Frazier (Akron), and Greg Hinze (Ft. Collins)

Sorghum experiments were conducted in Colorado in 1958 on the Arkansas Valley Branch Station at Rocky Ford under irrigation, on the Central Great Plains Experiment Station at Akron under dryland conditions, and on the Southeastern Colorado Branch Station at Springfield under dryland conditions. Most of the work consisted of yield tests of grain sorghum, sorgo, sudangrass, and broomcorn varieties. Some breeding work was conducted at Rocky Ford and at Akron.

Grain sorghums

Comparatively late hybrids generally have been most productive at Rocky Ford, possibly due to the fact that growth is continuous throughout the season because of irrigation. Hybrids that yield high include RS 590, RS 610, RS 620, Texas 611, and Texas 620. RS 501 has done well on the basis of one year's (1958) test. As an average for 1957-58, 19 hybrids outyielded 13 varieties by 16.5 percent.

Early and medium maturing hybrids produced equally high yields at Akron. The medium maturing hybrids produced somewhat shriveled grain of low test weight. Late maturing hybrids which had not reached the hard dough stage

when killed by frost were distinctly inferior in yield. The high open-pedigree hybrids in 1958 were RS 610, RS 501, Nebraska 41, CE 7018, and H 6542. The average yield of 26 hybrids was 40.0 bushels of grain per acre while that of 10 varieties was 34.3 bushels. Well-adapted varieties outyielded poorly adapted hybrids. The average yield of 36 varieties and hybrids in the Akron Variety Test Nursery was 51.0 bushels per acre on fallowed land and only 25.9 bushels following sudangrass.

Comparatively early hybrids also outyielded late hybrids under dryland conditions in southeastern Colorado at Springfield. The most productive open-pedigree hybrids in 1958 were RS 501, H 6542, RS 610, and RS 608. The mean yield of 16 hybrids was 17.4 bushels of grain per acre while that of 14 varieties was 13.1 bushels. Well-adapted varieties outyielded poorly adapted varieties.

Sorgos

None of the sorgo varieties grown at Rocky Ford in 1958 differed significantly in yield. The most productive varieties ranked as follows: RS 301F, RS 303F, 54HH370, Fremont, Early Sumac, and 54HH42.

The high sorgo varieties at Springfield were Axtell, Leoti, RS 301F, and RS 303F. There were no significant differences in yield.

There was a highly significant difference in the yield of the sorgos grown at Akron in 1958. Leoti and Fremont were the highest yielding varieties.

Sudangrass

Greenleaf was the highest yielding sudangrass variety at Akron. Two commercial purported sudangrass hybrids had a higher production than sudangrass but less than the better sorgos.

Broomcorn

A broomcorn variety test was conducted at Springfield in 1958. The test included four varieties: Clyde, Black Spanish, Rennels Dwarf No. 11, and Scarborough. Clyde produced the highest yield of desirable brush, with Black Spanish second. These varieties significantly outyielded the other two varieties.

Grain sorghum breeding work

Most of the sorghum breeding work was conducted at Rocky Ford in 1958; however, sorghum breeding was resumed at Akron following the appointment of Floyd W. Frazier as Assistant Agronomist at that station on July 1, 1958.

Several combine-type yellow endosperm grain sorghum lines have been isolated from some F_2 material furnished by the Hays Experiment Station several years ago. Some of these lines are homozygous for dry stalks while others appear to breed true for juicy stalk. Most of the lines are

comparatively late, but mature satisfactory at Rocky Ford. One or two lines are early. Some of these yellow endosperm lines may have promise in a sorghum hybrid breeding program.

As a technique study, a program also is underway to transfer the cytoplasmic male-sterile character from male-sterile Combine Kafir-60 to the Coes and Reliance varieties. The second backcrosses were made in 1958. Male-sterility has been transferred to these varieties without difficulty.

Some 93 lines of advanced generation sorghum hybrids were included in a program at Rocky Ford in order to evaluate them as breeding material. The lines, which included both grain sorghums and sorgos, were obtained from J. F. Brandon, formerly of the Akron Station. It has been found necessary to continue selection within many of these lines in order to obtain homozygous types.

A total of 42 relatively homozygous combine-type lines were crossed on four male-sterile strains, viz., m.s. Combine Kafir-60, m.s. Martin, m.s. Reliance, and m.s. Coes. The purpose was to evaluate the Akron lines as sterility maintainers or fertility restorers in order to use them later in a hybrid breeding program. The Akron lines are characterized by relative earliness and stiffness of stalk. They may prove valuable as parent material in early hybrids.

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FLORIDA (USDA)

Sugarcane-sorghum hybridization

Carl O. Grassl (Canal Point)

A sugarcane-sweet sorghum hybridization project has been underway at Canal Point, Florida, for the past few years. The main objective of this project has been to break down some of the barriers to gene exchange between *Saccharum* and *Sorghum*. A sugarcane-like plant with some of the early maturity and large seed size of the sorghums would be of considerable use to our sugar industry. For sirup production a sugarcane-like plant with the higher inversion character and greater invert sugar content as found in the sweet sorghums would be of advantage. Sirup sorghums with some sugarcane characteristics, such as the greater stalk density, cold resistance, and stooling ability, might be very productive. It is likely that forage plants of considerable importance may result as by-products of this research, and one can readily visualize some of the long-time potentials of increasing the yields of grain from complex sorghum-like plants. Since third-backcrossed plants with sorghum as the recurrent parent are now an actuality and limited material will soon be available for distribution to research workers, a short outline of the project follows.

In 1954, a few hybrids between a complex commercial sugarcane (clone F. 36-819) and a sweet sorghum were obtained. These proved to be highly sterile, so in 1956 a much larger number of hybrids (about 150) were obtained by the pollination of about 40,000 stigmas of F. 36-819 with pollen from Rex or Collier sorgo. One of the hybrids (clone U.S. 56-38-13) involving Rex as the male parent was found to be slightly female fertile and gave a small progeny (U.S. 57-230) when crossed with Wiley sorgo. All of the several first-backcrossed plants in question which flowered were male sterile, but a few gave a large number of seedlings when crossed with sweet sorghums. From a few crosses made early in 1958 with MN1054 or Mer. 55-14 as the sorghum parent, a few hundred seedlings, primarily from clone U.S. 57-230-6, were obtained. Slightly over 100 of these were brought to maturity and were studied the past season.

The 100 or so second-backcrossed plants which flowered were all male sterile in that there was no dehiscence of the anthers. They are extremely variable in appearance, particularly in vegetative characteristics. Female fertility appears to be very low, usually less than 1%. About 200 crosses involving these plants and various sweet sorghums such as Rex, Wiley, Tracy, Mer. 55-1, MN 960, and MN 1054 as the male parents have been made. The germination of the first 80 crosses has resulted in about 300 seedlings, so it is anticipated that a small population of third-backcross seedlings may be available for hybridization work this year.

Inasmuch as the male sterility found in the hybrids is disadvantageous for certain purposes, attempts will be made to produce amphidiploids from some of them in the hope that this will result in some male fertility. The chromosome number of none of the hybrids in question has been determined, but on a morphological basis it appears that the more usable F_1 plants are 2n + n in their makeup. This would mean that the F_1 used (U.S. 56-38-13) has about 120 chromosomes. The first-backcrossed plants look as if they may have about 70, while the second-backcrossed plants are smaller in general and are likely to have about 40 to 50 chromosomes. In time it may be possible to obtain a plant with the cytoplasm of sugarcane and only sorghum chromosomes.

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GEORGIA

A. R. Brown (Athens)

The effect of Gibberellic acid on Martin grain sorghum when applied at three different stages of growth was studied during the summer of 1958. The treatments were as follows:

Treatment 1 - check
Treatment 2 - soak seed 2 hours prior to planting (10 PPM)
Treatment 3 - spray when flowering (20 PPM)
Treatment 4 - spray biweekly after emergence (10 PPM)

There was no stimulating effect on the growth of the plants from these various treatments.

The variety Redlan was dropped from the recommended list of varieties for Georgia because of poor acceptance by growers. Combine Sagrain was added to the recommended list for Coastal Plains area. Wheatland was recommended for the mountains and Limestone Valley areas of Georgia because of its standing ability and yield. The hybrid DeKalb E 56a was also added to the recommended list.

Two College Experiment Station hybrids appear to be good yielders. These hybrids involve C. Kafir-60 m.s. and DDE Shallu and DD Schrock, and gave yields of 42 and 46 bushels per acre respectively in 1958. DD Schrock was thought to produce some sterility; however, this particular selection appears to restore fertility 100 percent. Its performance will be checked closely in 1959.

Since birds (English sparrow, blackbirds and starlings) prey on the maturing grain in the Southeast, farmers may have to use brown-seeded grain sorghums in order to obtain good yields. These grain sorghums have a relatively high tannin content which cause them to be somewhat bitter to both wild birds and chickens. However, work reported by Sieglinger et al, indicate broilers grow equally well on brown and white seeded grain sorghums. An experiment is being set up to study the effect of different tannic acid concentrations on broiler and egg production in hopes to find out whether brown seeded grain sorghums can be used by the ever-growing feed industry in Georgia.

Sorghum Silage Studies

J. P. Craigmiles, H. B. Harris, J. P. Newton, B. J. Johnson, M. E. McCullough and A. R. Stasch (Experiment)

Almost any crop suitable for hay can be made into silage. Many crops not readily adaptable for hay are good silage crops too. Most of these crops differ in their inherent ability to produce high per acre yields of silage material. The type of silage attained also differs with different crops. However, since the various classes of livestock have somewhat specific requirements, and these requirements can change with the condition under which the silage is fed, there is a need for silage from different crop species.

With this in mind, studies were initiated last year to determine the usability of highly productive *Sorghum* spp and sorghum hybrids as silage. Techniques for preserving small quantities of experimental silage and methods of measuring silage quality were also studied.

Thirty-six different *Sorghum* spp were planted June 25 in a randomized block design. This included several varieties of sorgo, forage sorghum, grain sorghum, F_1 hybrids of sudangrass, grain x forage sorghum, and sudangrass x grain sorghum.

At the proper stage of maturity these sorghum species were cut, weighed, and the leaf-stem ratio determined by hand separation. The material was then chopped with the use of a forage harvester and packed in 30-gallon pressed cardboard barrels containing plastic liners which formed a seal. Thermocouples were placed in each barrel for temperature readings and weights applied to the top of the barrel to simulate silo conditions. The percent moisture of the fresh material was determined as well as the chemical analysis.

The first week in December the silage was removed from the containers and scored using an adaptation of score cards used in Michigan and Minnesota. Information on 16 of the entries are summarized in table 1.

Preliminary results from this study show that in general good silage can be made from the sorghums tested. The pH was less than 4.0 in every trial except one. Desirable acid formation was also obtained. Results of the chemical analysis are not yet available.

Although yields were satisfactory, they were lower than what generally can be expected when these sorghums are planted at the recommended earlier planting date.

Thirty gallon drums appear to be satisfactory for preserving small quantities of silage. In preceding years ensilage has been of poor quality when preserved in quart fruit jars.

Table 1. Summary of silage notes.

	Green plant readings				Silage readings 3/			
	Height	Leaf-iness 1/	Matur-ity 2/	Green wt. per acre				
	in.			tons	pH	odor	color	mold
218E	70	2	4	14.7	3.7	25	20	20
Frontier 212	79	4	3	10.7	3.4	20	23	20
Frontier 5210	88	3	3	16.4	-	-	-	-
DeKalb 229MS x 1087	70	4	3	12.1	3.4	20	20	20
DeKalb 31-12 MS x 1087	90	2	3	17.2	3.2	20	20	20
DeKalb 12-7-2 MS x 1087	70	3	2	10.4	-	-	-	-
Sart sorgo	115	2	4	14.6	3.2	18	20	20
78E	80	2	3	23.1	3.4	20	20	20
Tracy sorgo	64	2	3	10.0	3.1	18	22	20
Combine Sagrain	46	4	2	7.8	-	-	-	-
Texas 660	56	4	1	7.3	-	-	-	-
173E	84	1	2	17.2	3.2	21	20	20
Ga. F_1 hybrid sudan	120	2	2	14.1	3.4	15	20	20
Ga. F_1 hybrid grain sorghum x sudan	96	2	2	12.3	-	-	-	-
DeKalb F_1 hybrid grain sorghum x sudan	106	2	1	14.9	-	-	-	-
Meridian 55-1 sorgo	118	2	4	14.0	3.0	20	24	-
LSD				3.4				

1/ Leafiness: 1, very leafy to 4, sparse leaves.

2/ Maturity: 1, early to 4, very late.

3/ Silage reading: possible score for odor-25, color-25, freedom from mold-20.
Excellent: silage 60-70 total points.
Good: silage 50-60 total points.
Low: silage 50 and less total points.

Natural Crossing in Two Varieties of Sorghum vulgare Pers. Under Georgia Conditions

H. B. Harris, B. J. Johnson (Experiment) and J. W. Dobson, Jr. (Blairsville)

The plant breeder is faced with the problem of adapting breeding techniques to the specific crop which he is trying to improve. In order to accomplish this efficiently, he must have a knowledge of the extent of

natural crossing which occurs in the crop under the conditions with which he is working. The seed grower is also concerned with the extent of natural crossing since it is his responsibility to maintain the purity of the crop.

Karper and Conner (3) reported that cross-pollination (natural crossing) among 41 lines of milo (strains of Sorghum vulgare) ranged from 1.68 to 35.00 percent, with an average of 6.18 percent in Texas. Plants entirely surrounded by the pollinator parent showed a higher percentage of crossing than plants not surrounded by the pollinator. Sieglinger (4) reported a variation of from 2.61 to 8.56 percent in cross-pollination between plants of a white seeded strain of milo when the male (pollinator) parent was planted on the windward side of the female parent. The average among all plants of the variety was 5.38 percent.

Hogg and Ahlgren (2) reported 6.70 percent cross-pollination in sudangrass (S. vulgare var. sudanense) at Madison, Wisconsin. Garber and Atwood (1) reported 76.40, 18.20, and 34.40 percent during the years 1941, 1942, and 1943 respectively, in sudangrass at State College, Pennsylvania. Karper and Quinby, as reported by Garber and Atwood (1), found that progeny rows of Leoti-sudangrass hybrids cross-pollinated from 7.00 to 72.00 percent in Texas, with an average percent natural crossing of 39.00.

Since these studies have been conducted outside the Southeast and with strains of S. vulgare different from those with which we are working today, it seemed advisable to investigate the extent of natural crossing that occurs in the crop under Georgia conditions.

Materials and Methods

Two varieties of S. vulgare, Midland-Waxy Kafir and Double Dwarf Early Shallu, were used as female parents in the study. Each female parent is characterized by tan pigment (recessive to red pigment) and white seed (recessive to "red" seed color). A blend of Midland, Redbine-60, and Redbine-66, which differ in time of pollen shedding, were used as the pollinator, or male parent. These varieties contain the dominant genes for the above characteristics.

Two methods of planting were used for each female variety. In the first the female was planted in alternate hills with the male so that each female plant was surrounded by the male parent. The female was planted in alternate rows in the second method so that the female was bounded on two sides by the male parent. These will be designated as hill and row planting respectively for the remainder of this paper.

The above treatments were arranged in randomized complete blocks and were replicated six times. Separate tests were planted at Experiment and Blairsville, Georgia, in the spring of 1957.

Seed was harvested from the center row of a three row plot. The seed from each female plant was harvested separately for each treatment at each location. These seeds were planted in the field at Experiment, Georgia, during 1958. Stand and hybrid counts were made at early dough stage of maturity. Percent natural crossing was computed by the following formula:

$$\text{Percent natural crossing} = \frac{\text{No. crossed plants x 2}}{\text{Total no. plants}} \times 100$$

Results and discussion

The data which represent the percent natural crossing that occurred in the two varieties of S. vulgare at Experiment and Blairsville are in table 1. Significant mean differences between hill and row methods of planting were not evident except in the Kafir variety at Blairsville. In that test, the greatest number of hybrids occurred in the hill planted Kafir. The other three means were not significantly different. This shows only partial agreement with the results reported by Karper and Conner (3) who found that plants surrounded by the pollinator had a larger percentage of crossed plants.

The average percent cross-pollination was 7.0 and 1.5 percent for the Kafir and Shallu varieties, respectively, when the data were combined from both locations. This indicates that the greatest differences occurred between varieties which is in agreement with results reported from Texas (1) (3).

The interaction between location and treatment was not significant; however, the F value obtained (2.48) was very near the value required (2.92) for significance at the 5 percent level.

The variation in cross pollination between individual plants (table 2) was similar in pattern to the average. The Kafir variety varied from 0 to 88.0 percent crossing, whereas the Shallu varied from 0 to 7.0 percent. This wide variability between plants within a variety agrees with the result reported by Sieglinger (4).

Table 1. The total number of plants and percent natural crossing for two varieties of sorghum vulgare planted in alternate hills or alternate rows with the pollinator at Experiment and Blairsville, Georgia.

	Midland-Waxy Kafir				Double Dwarf Early Shallu				Loc. average
	Hill (A)		Row (B)		Hill (C)		Row (D)		
Location	Total plants	Natural crossing	Total plants	Natural crossing	Total plants	Natural crossing	Total plants	Natural crossing	Natural crossing
	no.	%	no.	%	no.	%	no.	%	%
Experiment	11,590	7.8	16,634	9.2	16,461	1.6	20,465	2.2	5.2
Blairsville	8,470	7.9	15,884	3.2	9,753	1.1	19,929	1.2	3.4
Average	10,030	7.9	16,259	6.2	13,107	1.4	20,197	1.7	
Test average natural crossing									4.3

Natural Crossing Means

	(C)	(D)	(A)	(B)
Experiment	1.6	2.2	7.8	9.2
	(C)	(D)	(B)	(A)
Blairsville	1.1	1.2	3.2	7.9
	(C)	(D)	(B)	(A)
Two locations	1.4	1.7	6.2	7.9

Note: Any two means not underscored by the same line are significantly different at 5% level (Duncan's Multiple Range Test).

Table 2. Maximum variation between plants in percent natural crossing which occurred in two varieties of S. vulgare at Experiment and Blairsville, Georgia.

	Midland-Waxy Kafir				Double Dwarf Early Shallu				Location average	
	Hill		Row		Hill		Row			
Location	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	%	%	%	%	%	%	%	%	%	%
Experiment	0	33	0	44	0	3	0	6	0	22
Blairsville	0	88	0	48	0	6	0	7	0	37
Average	0	60	0	46	0	5	0	7		
Test average									0	29

Summary

A study was initiated at Experiment and Blairsville, Georgia, in 1957 to study the percent natural crossing which occurred in two varieties of Sorghum vulgare. Each variety was planted two ways, i.e., (1) each female plant was surrounded by the pollinator, and (2) each female was bounded on two sides by the pollinator.

Significantly different mean cross-pollination between the two methods of planting occurred in only one instance. In the Blairsville test, the hill planted (female surrounded by pollinator) Kafir produced a significantly greater number of hybrids than did the row planted Kafir. In all other instances the greatest differences were found between varieties. The variation between plants within a variety was similar to the pattern established by the average natural crossing.

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ILLINOIS (USDA)

C. W. Blessin, R. J. Dimler, and F. R. Senti (Peoria)

High-carotenoid sorghum

Past and current cooperative work with plant breeders engaged in the development of high-carotenoid sorghums is related to the feed utilization of this grain. One of the general classes of carotenoids, the carotenes, provides vitamin A activity and imparts yellow color to the milk and fat of cattle. The other major class, the xanthophylls, imparts yellow color to the skin and eggs of poultry.

The development at the Northern Utilization Research and Development Division of an analytical procedure based on chromatography and spectrophotometry for measurement of total carotenes and total xanthophylls in sorghum grain was reported in the first issue of the Sorghum Newsletter (Vol. 1, p. 41). Modifications now have been made in the procedure to adapt it to more routine measurement of these two classes of carotenoids in sorghum and corn. In addition, the modified procedure provides an estimate, if desired, of the relative amounts of other pigments which accompany the carotenoids in the initial ethanol extract. Interference from such pigments undoubtedly has been responsible for high results in the application of some earlier procedures for carotenoid determination.

During 1959 cooperative work of the Northern Utilization Research and Development Division with sorghum breeders will continue. Selected samples of yellow endosperm crosses will be analyzed for total carotenes, total xanthophylls, and other pigments to substantiate the suitability of the modified analytical procedure for sorghum grain. The data also will provide guidance for the sorghum breeder in his effort to raise the carotenoid content of sorghum from the normal level of about 1.5 parts per million to levels equal to or higher than in yellow corn (around 20-30 parts per million). The samples of crosses with "African yellow endosperm" varieties previously analyzed[1] showed a maximum of 9 parts per million of total carotenoids and demonstrated the adverse effect of exposure of the grain to weathering.

Water-soluble pigments of sorghum

A preliminary examination of the water-soluble pigments in certain varieties of yellow milo and red kafir indicated the presence of pigment precursors having at least some of the properties of the leucoanthocyanin class of compounds. Samples of other varieties, including White Kafir, Cody (waxy), Ellis (waxy), and yellow endosperm crosses from the 1956 and 1957 crop years, apparently contained little or none of these pigment precursors. When present, the leuco-compounds were found in the pericarp and were essentially absent from the endosperm of the grain. Extraction of the leuco- compounds with water was more effective when either the intact grain or the separated pericarp tissue was used than when the ground whole grain was used. In the latter case considerable adsorption of the leuco-compounds on the endosperm fragments presumably occurred. A procedure was developed for preparing a partially purified concentrate of leuco-compounds, and some preliminary data were obtained on the characteristics of the material.

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[1]Blessin, C. W., Van Etten, C. H., and Wiebe, Richard. Carotenoid content of the grain from yellow endosperm type sorghums. Cereal Chem. 35: 359-365. 1958.

Composition of cereal grains and forages

Compilation of the most reliable published data on the composition of cereal grains and forages, including sorghums and sudan grass, has been completed by the National Academy of Science under contract supervised by the Northern Division. This important source of compositional data has been published by the National Academy of Sciences, National Research Council, as Publication 585, "Composition of Cereal Grains and Forages", 1958. In this book, data in terms of 60 nutrients have been compiled for the various component parts of 325 genera and 700 species of plants, including both cultivated and range-type forages. Reported analyses totaling approximately one million analytical determinations served as source material for summary values presented. Tabulation has been divided into 9 parts: I, proximate composition; II A and II B, mineral composition; III A and III B, vitamin composition; IV A and IV B, amino acid composition; IV C, amino acid and hemicellulose composition; and V, energy and carbohydrate composition. Within each table, feeding stuffs have been classified according to form eaten as follows: (1) cereal grains, (2) dry roughages, (3) mixed hays, and (4) mixed silages.

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INDIANA

1958 Sorghum Research in Indiana

R. C. Pickett (Lafayette)

Wayne Whitehead assumed charge of the sorghum testing program including grain, forage, and sudangrass tests at the Sand Experiment Field in northern Indiana, Lafayette, and the Southern Indiana Forage Farm. In addition small trials are located on the muck in northern Indiana where it seems weed competition is the worst problem and on the poorly drained soils in east-central Indiana. A seeding rate of at least 10 lb. per acre will be used and recommended for cultivated row plantings on all of the better moisture sites in Indiana. Lower rates of 5 lb. per acre will be used in rows on the drouthiest sites.

Variety-rate-space-fertility trials in 1957 and 1958 revealed that 7-inch rows were significantly better than 14- and 21-inch rows in southern Indiana and at Lafayette. Populations of 360,000 plants per acre (30 lb. seeding rate equivalent) were higher in yield than lower populations for some hybrids (RS 610) and lower for others such as Tex 601 and Martin or Midland. The varietal interactions with these high population levels, row spacings, and fertility levels were significant. The moisture and fertility levels were high for these trials. The highest yielding plots

(average of all reps.) in 1958 were 208 bu./A. for RS 610 at 30 lb./A. rate in 7-inch rows at Lafayette and 176 bu./A. for RS 610 at 30 lb./A. in 7-inch rows on the Southern Indiana Forage Farm. An extra (beyond normal application) 100 lb. N/A. at seeding time being in the latter trial brought responses of 25, 20, and 43 bu./A. for RS 610 at 3 different populations of 120,000, 240,000 and 360,000 pl./A.

There is essentially no tillering of any varieties observed at these high populations. A sizeable proportion (10-30%) of the plants in 360,000 pl./A. plots had no heads even though the yield did not significantly decline in most cases.

The highest yield obtained in 1958 was in the weed control plot where 246 bu./A. (av. of 3 reps.) was obtained on treatment of 4 oz. of Simazin/A. This was RS 610 in 7-inch rows with about 180,000 pl./A. left after treatment. Simazin definitely caused some injury and significantly delayed maturity, but the weeds were completely controlled by the chemical and the complete leaf canopy later. Check blocks with weeds yielded only 88 bu./A. Observations in several trials indicated that even a very few weeds can reduce yield greatly at these high yield levels.

Wayne Whitehead has started a study in grain sorghum on combining ability as related to genetic and phenotypic diversity. The objective is to determine the effect of selection toward phenotypically diverse types on the components of yield. Seedling vigor, seed size, dryness of head, head type, and other characters will be considered. Two male steriles and 50 males were chosen to represent an array of types irrespective of adaptation. Included are lines which will permit comparisons with 2nd cycle selection of present hybrids.

Comparisons of Certain Sudangrass Synthetics and Male-sterile Grain Sorghum x Sudangrass Single Crosses

J. D. Clark (Lafayette)

Thirteen grain sorghum x sudangrass single crosses utilizing male-sterile Combine Kafir-60 as the female, twenty-three two-line sudangrass synthetics and thirty inbred parental sudangrass lines were compared. Characters studied were top growth dry weight, leaf dry weight amount, leaf percent, number of tillers, number of days to the boot stage of maturity, and rate of growth as measured by increase in natural height. The superior performing synthetic, single cross and inbred lines were compared with Greenleaf. Rate of growth as measured by increase in natural height was measured periodically from one month after planting until the first line reached the boot stage of maturity.

Table 1 lists the overall means of each type. The single crosses as a whole were earlier and gave a greater yield than the selfed lines. They were earlier than the synthetics but did not differ significantly in yield. The synthetics were superior to the single crosses in leaf percent, leaf amount and number of tillers. The selfed lines were later in maturity and lower in yield than both the single crosses and synthetics but had a higher leaf percentage.

The single crosses, as shown in table 2, were significantly superior in performance to Greenleaf for earliness of maturity, dry weight and leaf amount. There was no significant difference in leaf percent, but a significantly lower number of tillers was observed. The highest synthetic did not differ significantly from the highest single cross in earliness of maturity, topgrowth dry weight or leaf amount, but it was superior in leaf percent and number of tillers. The highest ranking synthetic was above Greenleaf in all characters.

The superior selfed line was significantly higher than Greenleaf in leaf percent and number of tillers.

The single crosses grew much faster in height than the synthetics, selfs and Greenleaf (table 3). The synthetics and Greenleaf had a parallel growth while the selfs were shorter than all of the others.

Table 1. Summary of type comparisons for maturity (in days from planting to boot stage of maturity), topgrowth dry weight, (in grams), leaf percent, leaf amount (in grams), and number of tillers per five plants.

Type	Maturity	Dry wt.	Leaf %	Leaf amount	No. of tillers
Single crosses	65	387*	44	168	13
Synthetics	71*	421*	52	216	53
Selfs	73*	244	56	136	39

*Non-significant difference.

Table 2. Summary of 5-plant performances of superior entries of each type and of Greenleaf.

Type	Maturity	Dry wt.	Leaf %	Leaf amount	No. of tillers
Single cross	60	639	50.1*	276	19
Synthetic	63	615	61.3	312	79
Self	64*	337*	62.2	182*	73
Greenleaf	67*	198*	51.4*	100*	35
L.S.D. (5%)	6.9	125.2	9.9	65.1	14.6
(1%)	9.1	164.1	13.0	85.5	19.2

*Non-significant difference from Greenleaf.

Table 3. Summary of mean rate of growth for each type as measured by increase in natural height in inches.

Type	Date of measurement								
	7/17	7/21	7/24	7/27	7/31	8/2	8/6	8/9	8/13
Single crosses	17	21	26	34	45	52	65	70	83
Synthetics	12	16	19	24	31	35	44	47	59
Selfs	11	13	15	20	25	28	36	40	50
Greenleaf	13	16	17	24	29	34	44	47	57

Research on Sterility

Bruce Maunder (Lafayette)

Investigations on male sterility are being continued. The first objective was to isolate the male-sterile phenotype which was found to be controlled by a single gene, ms_c (Agron. Jour. Vol. 51, pp. 47-48). Present research is concerned with variability in the fertile class. Although readings from bagged heads are essential for large populations, they are quite misleading inasmuch as the pollen phenotype is concerned. An accurate phenotypic classification, which can be improved through pollen readings, is essential for a meaningful genetic hypothesis concerning this fertile variability.

"Blasting" or floret abortion which occurs in varying amounts on the heads of male-sterile C.K. 60 is being investigated for both basic and applied purposes. This extreme form of both male and female sterility appears to also be dependent on a cytoplasm - genetic interaction.

Both a gene and cytoplasmic frequency study has been initiated. Ninety-nine forage and grain sorghum varieties and five sudans are being tested using the composite pollen technique. Selection pressure on a sterile mutant gene (ms_c) should be of little consequence in a normal cytoplasm background. Information from this study may also help to clarify the above problems.

Preliminary Investigations on Panicle Shape

Bruce Maunder

To obtain a better understanding of the genetic control of panicle shape (degree of head opening) in grain sorghum, three open types crossed with male-sterile C.K. 60 were selfed and the parents, F_1's and F_2's grown in the field in 1958.

The following results apply only to the experimental line 7861 as the other two open types failed to meet many of the assumptions for a desirable quantitative study. As this was a preliminary investigation, it was essential to find a reliable measure of head opening. Both a rating system (1= open - 9= compact) and a head height by widest width ratio were used.

Analysis for gene number was done with Castle's formula:

$$n= \frac{.25(.75-h+h^2)D^2}{Q^2F_2-Q^2F_1} \qquad h= \frac{\bar{F}_1-\bar{P}_1}{\bar{P}_2-\bar{P}_1} \qquad D= \bar{P}_2-\bar{P}_1$$

The F_1 consisted of 54 plants; the F_2 of 155.

Results

		$\bar{X}$	Q^2	No. of genes
1. Rating system:				
	P_1	3.0	-	-
	P_2	9.0	-	-
	F_1	5.44	1.94	-
	F_2	5.94	4.14	3.64
2. Measurements:				
	P_1	2.03	-	-
	P_2	3.68	-	-
	F_1	2.93	0.40	-
	F_2	3.27	1.19	3.28

The F_2 extremes were used for the gene number estimate rather than parental means in order to better fulfill the assumption of one parent having all the plus genes and the other all the minus genes.

The F_1 distribution was quite normal with the F_2 distribution somewhat bi-modal based on measurements. The rating distribution was skewed to the right (compact heads) with both the F_1 and the F_2 populations. The three F_2 selfs which made up the population were also analyzed separately and had measured variances of 1.12, 0.88 and 1.10.

To further test the two methods of classification, the following correlations were found:

Population	d.f.	r.
F_1 rating vs. F_1 measured	52	0.68**
F_2 rating vs. F_2 measured	153	0.75**

Obviously not all the assumptions of Castle's formula were met, but as most of them under estimate gene number if they are not, it seems likely from this population that at least 4 genes control this characteristic of the panicle. Head opening is, however, influenced directly by such things as seed size, head density, and time of maturity.

It appears that for a more intensive study, which might include moisture correlations, height-width ratios may be used in place of ratings to measure head opening.

Sorghums in Southern Indiana

M. E. Heath (Lafayette)

Due to interest of sorghum in Southern Indiana, on our Southern Indiana Forage Farm we have tried to work out cultural methods whereby this crop can be used more extensively both for grain and forage. The topography is steeply rolling. Clean row tillage has proven disastrous on many of these farms in the past.

Field observations on the Forage Farm indicate that it is practical to grow both the forage and grain sorghums in uncultivated close row spacings (14-21 inches). Presently we are experimenting with a double cropping system using vetch-cereal for the winter crop for silage and this followed with one of the close drilled sorghums using a stubble mulch seedbed. One of the reasons that sorghums look promising for this unglaciated sandstone-shale area is the fact that summer drought is frequent. Corn is often damaged by the extent of the drought while the sorghums will go dormant but recover as soon as moisture becomes available.

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IOWA

Grain Sorghum Research and Testing

R. E. Atkins (Ames)

The Iowa grain sorghum performance tests were conducted for the first time in 1958 as a cooperative project of the Agronomy (Farm Crops) Department and the Iowa Crop Improvement Association. A total of 127 hybrid entries were submitted for testing at the six locations by seven commercial grain sorghum seed producers, and part of the costs for conducting the tests were financed through fees collected from each entrant. The uniform regional yield nursery and the regional observation nursery were grown at Ames. Weather conditions during most of the growing season and during the harvest season were very favorable for sorghum production and yields were high. The average yield for all grain sorghum hybrids tested at all locations in 1958 was 100 bushels per acre, while the average yield for an adapted corn hybrid for the six locations was 112 bushels per acre. During the 3-year period 1956-58 the average yield for all grain sorghum hybrids in 14 tests has been 89 bushels per acre as compared with an average yield for the corn check plots in the same tests of 90 bushels per acre. Grain sorghum hybrids generally have equaled or exceeded corn in yield at the western and southern Iowa locations, while corn generally has exceeded grain sorghum in yield at Ames. Results of these tests are available in Agronomy Leaflet 456.

Rate of moisture loss from the grain and five other plant parts was studied using six grain sorghum hybrids and varieties at Ames in 1958. The initial harvest was made when the grain moisture content for all entries was between 47-52 percent, and ten harvests at five day intervals were made during September and October. Results of this study have been summarized in the M.S. degree thesis of Mr. Ivan Wikner. Rate of water loss from the grain was not consistently associated with rate of water loss from the pedicles, rachises, peduncles, leaves or stalks for any of the six entries studies. A regression analysis of loss of moisture from the grain indicated that the rate of moisture loss did not differ significantly among the varieties and hybrids tested. Loss of moisture from the pedicles, peduncles, rachises and leaves was accelerated greatly after the occurrence of frost and a 29° F. low temperature on October 1, while rate of water loss in the grain and stalks was not altered by the frost. An analysis of 200-kernel weight determinations from successive harvests indicated that sorghum grain attains its maximum dry weight when the grain is harvested at moisture percentages of 31 to 39 percent. Entries differed somewhat in this regard with Norghum and Midland attaining maximum dry weight of the grain when harvested between 31 and 35 percent grain moisture, while a range of 34 to 39 percent grain moisture at harvest produced maximum dry weight of the grain for Martin, Double Dwarf Yellow Milo, RS 610 and DeKalb C44a.

The effects of freezing sorghum grain at varying moisture contents for different durations of time at several temperatures was investigated in 1958 by Mr. Gerald Carlson as a thesis problem for the M.S. degree. The hybrids RS 501 and RS 610 and the varieties Norghum and Combine Kafir-60 were studied using grain at several moisture levels from 45% downward. These samples were placed in cold chambers at 26° F., 20° F. and 14° F. for periods of from 4 to 72 hours and then evaluated for germination percent and seedling vigor. Two phases of the study are being conducted, one using normally dried seed resoaked to specific moisture contents prior to freezing, and the second phase using grain harvested in the field as it reached the specific moisture contents desired. This thesis should be completed in June 1959 and results available for presentation in next year's report.

Evaluation of the effectiveness of pre-emergence application of selective herbicides on weed control and on grain sorghum stands and yields was continued at Ames in 1958, in cooperation with Dr. D. W. Staniforth of the Botany Department. In both 1957 and 1958 Randox applied at a 4 lb./acre rate gave very good control of weeds and did not reduce stands or grain yield of the sorghum. Simazin at 2½ and 5 lb./acre rates also has been tested in both years, with good weed control obtained in both seasons. However, the lower rate of application reduced sorghum yields 12%, and the higher rate reduced yields 30% during the two-year period. Applications of 2,4-D ester at 2 lb./acre also reduced yield of the sorghum approximately 30% during the two-year period and was somewhat less effective in controlling weeds. Randox T was tested only in 1958 and found to be very effective in weed control and did not damage the sorghum when applied at a 4 lb./acre rate. Eptam, applied at 3 lb./acre, reduced stands by about 50% and yield by 20% in 1958, while the 6 lb./acre rate of Eptam reduced stands by nearly 90% and yields by 50 percent.

The evaluations for resistance to second brood corn borer initiated in 1957 in cooperation with Dr. F. F. Dicke of the Regional Corn Borer Laboratory, Ankeny, Iowa, were continued in 1958. A wider selection of sorghum germ plasm was infected during the past season, including representatives of the milo, kafir, hegari and feterita sorghum types. Readings for sheath lesions, and peduncle and internode cavities were obtained for 34 entries. Double Dwarf Yellow Sooner Milo had a markedly higher composite infestation score in 1958 than any of the other entries. Resistant D. D. Yellow Milo and Texas Milo also gave very high composite readings for infestation in 1958. Tx 620, RS 590 and Tx 611 were lowest in composite infestation in 1958, but they had been intermediate in infestation in 1957. Reliance was among the lowest in infestation in the 1957 tests but was relatively high in composite readings in 1958. Thus the results obtained must be considered only as a preliminary evaluation, and the degree and importance of seasonal variations and other limiting factors will need to be investigated.

A study of effects of artificially drying sorghum grain at 100-105, 115-120, 135-140 and 160-165° F. when harvested at moisture contents of 40-45% down to 15-20% over a six week period during September-October 1957 was carried out at Ames and summarized during the past season. Eight harvests each were made from RS 501 and Tx 620 hybrids and from the Combine Kafir-60 (ms) rows of a seed production field of RS 501. Control of drying temperatures was not very precise with the equipment available, and the study was conducted only for one season. Thus conclusions about effects of the drying temperatures should be tempered with these limitations in mind. The results indicated that grain artificially dried at temperatures of 160-165° F. was seriously reduced in viability as measured by seedling emergence counts obtained from the dried grain and from air-dried check plots. Drying temperatures of 100-105° and 115-120° F. did not impair viability of the seed in these tests.

Conclusions about the advisability of drying grain sorghums at 135-140° F., when the grain is to be used for seed, were more difficult to make in view of the variability that occurred in the results for this temperature range. In some cases grain was dried at 135-140° F. without serious reduction in viability, but marked reductions in viability occurred in other instances at this temperature. The 135-140° F. range apparently is at or near the upper limit of safe drying temperatures for seed purposes, and any appreciable period of temperatures above the 140° F. level may result in marked reduction in viability. Moisture content of the grain also appeared to be a more critical factor at this temperature. Grain of approximately 25% or less moisture was less seriously damaged than was grain containing more than 30%, moisture. Kernel plumpness, as measured by 100-kernel weights, was not appreciably affected in these studies either by moisture content at the various harvest dates or by drying temperatures.

Other studies continued at Ames in 1958 included the plant population and nitrogen fertilizer experiment described in last year's report and a planting date study. In 1957 grain yield did not differ greatly for the first five plantings at weekly intervals from May 22 through June 19, but dropped off markedly for the June 26 planting. Yields obtained in 1958 showed a marked decrease after the first planting on May 14, then were essentially alike for the next three weekly plantings, and again were drastically reduced at the fifth and sixth planting dates (June 11 and 18). The sixth planting date in 1958 returned only 57 percent of the yield obtained at the first planting date. These results reflect the comparative growth and maturation conditions in the two seasons. Conditions were favorable for continued plant and grain development well into the fall season in 1957, while lack of moisture and warm temperatures in September and October in 1958 sharply curtailed grain development in the late planted entries.

Breeding work initiated on a limited scale in 1957 was expanded somewhat in 1958. A considerable number of crosses using a variety of pollinators were made on the male-sterile lines of Combine Kafir-60, Martin, Wheatland, Redlan and Reliance. Several large-seeded types from Egypt and India which were crossed with the Combine Kafir-60, Martin and Wheatland male-steriles in 1957 were observed to produce at least partially fertile hybrids, and the resultant hybrids were back-crossed to all three steriles this season.

Performance of Forage Sorghum Varieties and Hybrids in Iowa

R. R. Kalton (Ames)

Forage sorghum tests comparing hybrids and varieties have been underway for several years in Iowa. At Ames in 1958 the highest yielding variety and hybrid were Waconia Orange and RS 301 with yields of 23.7 and 23.1 tons per acre, respectively. RS 610 grain sorghum yielded 14.5 and Iowa 4570 corn 20.3 tons in the same test. Grain percentage in the forage at harvest varied from 0% in RS 301F and RS 303F to 11% for Waconia Orange to 17% for FS 210 to 20 to 24% for most sorgos up to 39 to 41% for Hegari, Dual and RS 610. Corn had 30% grain. At Albia, RS 301 and Waconia Orange were the high hybrid and variety with 26.1 and 23.0 tons per acre, respectively. RS 610 yielded 14.1 and corn (AES 801) 23.6 tons per acre. At Cresco, in northeast Iowa, cool weather gave poor growth and Iowa 4417 corn was best at 17.5 tons per acre with RS 301F, Waconia Orange, and RS 610 yielding 14.2, 13.4 and 10.4 tons per acre, respectively.

In all tests the last three years, RS 301F has been the only adapted hybrid tested which has been high in yield, good in lodging resistance and satisfactory in maturity whether bagged to prevent seed set or not (see table 1). RS 302F also has shown good hybrid vigor but always lodges badly. RS 303F generally has been poorer than its male parent, Axtell, in yield while FS 210 performs about like Atlas. Certain commercial hybrids have yielded well and been high in grain percentage, but often they have been too late or deficient in lodging resistance. A complete summary of results for the last three years is available on request from the Agronomy Department, Iowa State College, Ames, Iowa.

Table 1. Two year average performance of several forage sorghum hybrids and varieties and a grain sorghum hybrid at Ames and Albia, Iowa.

Variety or hybrid	Ames 1957-58 averages Bloom date	Lodging (%)	Grain (%) 1/	Tons/acre (70% moisture)	Albia 1957-58 average Tons/acre (70% moisture)
Rox Orange	8-18	2	22	18.4	--
RS 301F	8-16	7	Trace 2/	21.8	23.7
Leoti Red	8-15	37	23	19.4	--
RS 302F	8-14	46	24	22.8	--
Axtell	8-17	10	22	21.1	19.4
RS 303F	8-16	1	Trace 2/	18.5	17.1
Atlas	8-23	26	23	19.3	20.8
FS 210	8-19	11	No data	20.4	20.0
RS 610	8-11	0	40	12.4	12.0

1/ Dry weight percentage of grain at harvest.
2/ Bagged to prevent seed set.

Performance of Sudangrass and Other Tall Sorghum Grasses at Ames, Iowa, 1958, When Cut on Hay or Silage Basis

R. R. Kalton

Several sudangrass varieties and several miscellaneous tall sorghum grasses were grown in cultivated rows at Ames in 1958 and cut twice to simulate hay or silage yields. First cutting was made at bloom stage and the second at bloom stage or frost. Yields are shown in table 1 in comparison with previous performance of the sudans under a simulated pasture clipping system.

It is obvious that performance of sudan varieties varies considerably depending on harvest method as illustrated by the complete reversal of Wheeler. Sorghum almum yielded well under this cutting system but may not do as well under a simulated grazing system.

Table 1. Performance data of sudangrass and other grass sorghums.

Entry	First cut Date	First cut Leafiness %	First cut T/A	Second cut Date	Second cut T/A	Total yield T/A	1955-56 Pasture cut T/A
Sudan							
Lahoma	8-23	26.4	3.28	10-1	.46	3.74	2.04
Piper	8-10	27.0	2.38	9-20	1.14	3.51	2.31
Greenleaf	8-17	31.2	2.40	10-1	.66	3.06	1.99
Sweet	8-13	28.9	2.06	10-1	.44	2.50	1.87
Wheeler	7-31	32.6	1.30	9-4	.99	2.30	2.35
Others							
Sorghum almum	8-14	26.2	3.20	10-1	.84	4.03	
Per. Sweet Sudan	8-14	31.2	2.14	10-1	.44	2.58	

T/A = tons per acre oven-dry weight.

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ISRAEL

I. Arnon (Rehevot)

It may be of interest to your readers to know about the major contribution made to the agriculture of Israel by the U.S.A. "tailor-made" combine sorghums.

Durra has been grown since time immemorial in this country, but because of low yields and, in particular, because of the need of harvesting by hand, the crop never became popular with progressive farmers.

The crop rotation generally practiced here is a three-year course rotation - winter cereals, summer crops, and legumes for hay. The summer crops grow from April to August. During this period not a drop of rain occurs, so these crops have to subsist entirely on moisture stored during the previous winter. Under these conditions the only grain crop available a few years ago was corn which produced relatively low yields under favorable conditions and none at all in the drier areas of the country. In practice large areas, therefore, remained fallow.

The introduction of the combine sorghums a decade ago from the United States caused quite a revolution in our farming practices. They very rapidly became the major summer crop, producing stable and relatively high

yields. However, last year when I summarized the results of 10 year's work on varietal introduction and testing, we found that the two varieties which had proved outstanding in our trials 10 years ago (Martin and D.D. Yellow Sooner) still headed the list, notwithstanding the considerable number of varieties tested since then.

It was the new sorghum hybrids which enabled us to break this "sound barrier." The very first trials in 1957 gave such promising results (increases in yield of 40% and above) that we recommended fairly large scale sowing by farmers in 1958, using U.S.A. produced hybrid seed (Frontier 410). Our seed producers have started producing hybrid seed locally (RS 610), and we have initiated our own breeding program to develop locally adapted hybrids.

We are also studying rather extensively various aspects of sorghum production problems such as irrigation, fertilizers for dryland crops and under irrigation, soil compaction, plant populations, etc.

I do not know in how far you may be interested in the results of these experiments or whether they are of local interest only. We now sow sorghum on 60,000 acres approximately, certainly a small area by American standards, but quite an important fraction of the cultivated soils of our small country.

I am happy to take this opportunity to express our appreciation of the generosity with which your sorghum plant breeders have made available to us all the germ plasm and information we have requested from them. This has enabled our farmers to grow hybrid sorghum almost simultaneously with the American farmer. It is my hope that we may be in a position to reciprocate sooner or later the help received.

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KANSAS and USDA

Certified Production in Kansas, 1958

Wayne Fowler and Tom Roberts (Manhattan)

The acreage of all sorghum approved for certified seed production in Kansas in 1958 dropped to 3,518, only 34% of the 1957 acreage. There were approved 1,082 acres of forage sorghum, 2,047 acres of grain sorghum, 271 acres of sorghum hybrids, and 118 acres of sudangrass. Limited acreages producing seed of three new sorghum hybrids, KS 602, KS 603, and KS 701, were inspected for certification.

The year 1958 was only fair for sorghum seed production in Kansas. Many fields were late because of unfavorable spring conditions in the

southwest and because of the cool, wet summer, which tended to delay development. As a consequence, an October 1 freeze apparently reduced the vitality of several seed lots.

Seed Treatment Studies

Earl D. Hansing (Manhattan)

Experiments conducted in 1958 in general confirmed those which were conducted during the previous 3 years. The highest increases in emergence were obtained with combinations of either the fungicides captan or thiram and the insecticide dieldrin (Captan Dieldrin, Orthocide Dieldrin, Delsan A-D, and Panoram D-31). Next highest was obtained with the nonmercurial fungicides captan (Captan 75 and Orthocide 75) and thiram (Arasan 75 and Panoram 75). High emergence also was obtained with the fungicide-insecticides Panogen 15 and Drinox (aldrin), and with the mercurial fungicides, Panogen 15 and 42; Ceresan 75, 100, and 200; and Ceresan M and M-2X.

Sorghum Production and Physiology

F. C. Stickler and A. W. Pauli (Manhattan)

Fred Stickler replaced Dr. H. H. Laude as of July 1, 1958. Dr. Laude retired after many years of service to Kansas agriculture.

Kernel development

Mr. Jack Kersting is studying moisture, dry weight and chemical changes during development of the sorghum caryopsis for his M.S. thesis. Samples were taken in Combine Kafir-60 at pollination and every three days thereafter until the moisture percentage approximated 15%. This study will be continued and enlarged in 1959.

(1) Maximum dry weight occurred at 45 days after pollination when the moisture content was 23 percent. Near-maximum dry weight was noted at 30 days or about 40 percent moisture.

(2) Percent of total, non-reducing and reducing sugars were low soon after pollination, reached a maximum at 12 days, decreased rapidly until 21 days and remained at a rather constant low level thereafter. In general, the level of non-reducing exceeded that of reducing sugars.

(3) Acid hydrolyzable carbohydrates made up 33 percent of six-day kernels and increased to 85 percent at 45-48 days. Starch comprised 2 percent of six-day caryposes and steadily increased until it occupied about 70 percent of the dry weight at 42 days.

(4) Nitrogen percentage decreased from 2.7 for six-day material to 2.1 percent at 12 days, and varied from 2.2 to 2.4 percent thereafter. Mg/100 kernels of N steadily increased from 3.5 (6 days) to 70 at 42 days.

(5) Sorghum kernels harvested 15 days after pollination exhibited 75 percent germination. Seed treatment (Spergon) was beneficial on seed harvested prior to 24 days and not thereafter. Maximum laboratory germination was found with 27 to 36 day material.

(6) In the greenhouse in soil, maximum emergence was obtained from material sampled in the 33 to 42 day range. Marked differences in seedling weight (harvested at 18 days after planting) were noted. Individual plant weights (dry weights of tops in mg) varied from 2.9 for 15 day material to 19 mg/plant for seed harvested 42 days after pollination.

Row spacing - plant population

This type of study was initiated by Dr. H. H. Laude in 1944. In 1958 with very favorable rainfall, yields did not differ significantly between plant areas of 80 and 120 sq. in. Conditions were such that tillering, seed size, and number of seeds/head compensated for differences in plant area.

Uniform spacing - population experiments within each of three sections (East, Central, West) of the state are planned in cooperation with Branch Station and Experiment Field personnel for 1959. Depending on the section, either 5 or 6 plant populations in both 20 and 40 in. rows are planned.

Optimum plot size studies

Two uniformity trials were set out at Manhattan in 1958 to obtain yield data with which to estimate optimum plot size and shape. Examination of C.V.'s and comparable variances without consideration of cost data suggested that a harvested plot area equivalent to one row (40 in.) 20 or 25 feet long would give reliable results.

Defoliation experiments

Three tests were initiated in 1958. The first was designed to determine the contribution of individual leaves of the sorghum plant when defoliated at the late boot stage. The results indicated that as leaf area is removed, the remaining leaves photosynthesize more efficiently. For example, removing half the leaf area resulted in only 33 percent loss in yield. The relationship between yield and leaf area was curvilinear.

The major objective of the second experiment was to study possible interaction between degree of defoliation and stage of growth at which approximately 1/2 of the leaf area was removed by different methods.

The defoliation treatment x stage interaction was significant for most agronomic characteristics studied such as grain yield, number of heads per unit area, and seed size.

A third experiment was initiated to follow nitrogen and carbohydrate trends following different defoliation treatments applied at boot and anthesis stages of development. Samples were taken at 10 day intervals. Although nitrogen percentage and N yield (% N x dry matter) were reduced by defoliation, the rate of N uptake following defoliation was not materially influenced by leaf removal except where all leaves were removed. Carbohydrate analyses have not been completed.

Phenology

Six genotypes were planted on three dates at eight locations in Kansas by Experiment Stations and Experimental Field personnel in order to obtain data on time from planting until 50 percent bloom for the various varieties. The main objective is to study the effect of temperature on time required for blooming. Results from 1958 indicated that calendar days were no more variable in predicting bloom date than was any heat unit summation system attempted. As would be expected, a variety x location interaction was evident. Analysis of these data has not been completed.

Grain yield and other data were collected from the above mentioned test at Manhattan. As expected, the date of planting x genotype interaction was significant for most agronomic characteristics studied, such as yield, the three components of yield, (heads per unit area, seeds per head, and seed size), contribution of tillers and the difference in seed size of grain harvested from main heads as compared with that from tillers. The yields of Midland were less influenced by planting date than were yields of other varieties. This was due to stability in the number of heads per unit area and to the compensating effect of changes in seed size by opposite changes in the number of seeds per head.

Plans for 1959

In addition to the above experiments which will be continued, the following tests will be initiated in 1959, resources permitting:

(1) A study to evaluate the influence of Gibberellic acid on emergence and seedling growth.

(2) The emergence and early growth of grain sorghum at various temperatures with emphasis on the Kaoliangs (cooperative with A. J. Casady).

(3) Main stem - tiller interactions at different levels of defoliation.

(4) Field vs. laboratory germination.

(5) Stand establishment and plant distribution as influenced by different planting methods.

(6) Varietal response to different fertility levels.

Grain Sorghum Protein Analyses

Ted L. Walter (Colby)

Answers to questions concerning the relative feeding value of grain sorghum hybrids versus standard varieties are not readily available in printed form. Similarly, very few figures can be found comparing the feeding value of grain sorghum grown on dryland versus sorghum grown under irrigation.

Protein is one of the important constituents of feed grain that can be rather easily measured in a laboratory with ordinary testing equipment. Therefore, a preliminary study was initiated at Colby during the winter of 1958-59 in an attempt to determine if important differences in protein content could be detected between hybrid vs. standard varieties and/or dryland vs. irrigated samples.

Table 1 contains the principle results of this preliminary study. The results from duplicate samples were averaged to give the protein percents stated in the table. The grain samples and yield results given in the table were taken from the 1958 irrigated and dryland tests at Colby.

In general, it appeared that grain sorghum hybrids have somewhat lower protein percentages than standard varieties when grown on either summer-fallowed or irrigated land. Differences in protein between summer-fallowed and irrigated samples were not consistent, and average figures indicated very little difference. It is to be expected that differences might be considerably greater in a less favorable season. Perhaps the effects of nitrogen applications can be investigated in future tests. The irrigated test in 1958 received about 100 pounds of nitrogen per acre in the form of ammonium nitrate. The dryland test received none.

Both standard varieties and hybrids yielded considerably more pounds per acre of protein when grown under irrigation, but it was more pronounced in the case of the hybrids.

Protein analyses were run in the Colby Experiment Station Laboratory by W. W. Harris.

Table 1. Protein analyses of dryland and irrigated grain sorghum varieties and hybrids.

	Summer fallowed			Irrigation		
Kind	Yield	Test weight	Protein	Yield	Test weight	Protein
	lb./A.*	lb./bu.	Pct.*	lb./A.*	lb./bu.	Pct.*
Martin	3254	59.0	12.38	5242	60.0	11.79
Coes	3030	59.5	11.74	--	--	--
Norghum	3702	58.5	11.28	--	--	--
Midland	3847	58.0	11.21	4508	59.0	11.77
Average	3458	58.8	11.65	4875	59.5	11.78
RS 590	4026	57.5	11.65	5550	59.5	11.48
RS 630	4861	56.0	10.72	6474	58.0	10.67
RS 608	4424	58.5	10.54	6328	60.0	11.71
RS 650	4133	55.0	10.54	5869	58.5	9.85
RS 610	4883	58.0	10.50	6530	59.0	11.00
Average	4465	57.0	10.79	6150	59.0	10.94

*Grain yields and protein (N x 6.25) were corrected to 12.5% moisture basis.

Stigma Receptivity in Cytoplasmic Male-sterile Sorghum

W. M. Ross (Hays)

As a corollary to the study made in 1956 of stigma receptivity in male-sterile heads under bags, a study was made at Hays, Kans., and Lincoln, Nebr., in 1958 of stigma receptivity in unbagged heads. Two dates of planting were made of Combine Kafir-60, Martin, and Westland in isolation in the garden area of the station.

Unfortunately, Westland shed considerable pollen and contaminated the first date of planting causing abandonment. Pollinations were carried out successfully with the second date after Westland was cut out. The period of pollination ran from August 27 through September 5. Four heads of each variety were pollinated on each day. All heads except those to be pollinated were bagged each day and the bags removed when pollination was completed. It was found that Martin required 6.5 days to complete blooming while Combine Kafir-60 required 6.6.

The experiment is summarized in table 1. The data were not very erratic except for Combine Kafir-60 at 3 days and Martin at 0 days. It was surprising to find a trace of seed after eight days. This might have been due to pollen blowing in or to the removal of bags too soon after pollination.

From the data it appears that Martin loses its receptivity slightly sooner than Combine Kafir-60. The trend was also noticed at Lincoln for Martin and was very distinct for Westland. If semi-compact heads like Combine Kafir or Redlan have an advantage in receptivity over loose-headed types like Martin, Wheatland, and Westland, then seed set becomes more of an economic factor and actually will determine the hybrids that go into production.

The experiment needs to be repeated, preferably under more severe growing conditions than were found in the favorable 1958 season. Even so it is apparent that stigma receptivity is relatively shorter when exposed to the elements as compared under a bag.

Table 1. Summary of stigma receptivity study, Hays, Kans., 1958.

Days after full bloom	Estimated seed set			Wt. of seed per head		
	Combine Kafir-60	Martin	Av.	Combine Kafir-60	Martin	Av.
	%	%	%	gm.	gm.	gm.
0	89	44	66	57.0	17.5	37.0
1	83	78	80	47.0	39.5	43.0
2	69	65	67	37.0	30.0	33.5
3	85	70	78	55.0	37.0	46.0
4	76	38	57	38.5	24.0	31.0
5	65	48	56	39.5	19.0	29.0
6	34	22	28	20.0	10.5	15.0
7	15	5	10	10.0	7.0	8.5
8	tr	tr	tr	5.0	4.0	4.5
9	tr	tr	tr	4.0	3.0	3.5
10	tr	tr	tr	2.0	2.0	2.0

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KENTUCKY

Silage Production Experiment

J. F. Shane (Lexington)

Tests to determine the relative production of various sorghum varieties for silage were conducted on the H. B. Ferguson farm at Franklin, Kentucky, in 1958. The yields are reported in terms of dry matter per acre and are presented in the following table:

Table 1. Forage sorghum yields, Franklin, Kentucky, 1958.

Variety or hybrid	Dry matter per acre (tons)	Percent of plant in the head
Sart	11.98	11.8
Tracy	6.16	--
Sugar Drip	6.37	--
Atlas	5.30	--
FS-1	7.68	46.8
L.S.D. .05	.96	
.01	1.33	

The forage sorghum hybrid FS-1 and the variety Sart were the only entries with good seed heads. Tracy, Sugar Drip and Atlas had very little or no seed.

Sudangrass Variety Test

W. H. Stroube (Lexington)

Yield and other performance data of sudangrass varieties were taken at the Woodford County Farm and Western Kentucky Substation in 1958. The varieties were drilled in plots with 9 - 7" rows and the center 5 rows harvested. Piper, the variety recommended for use in Kentucky, continued to be satisfactory in yield and disease resistance and recovered more rapidly after clipping than other varieties tested.

Table 1. Sudangrass varieties, tons dry matter per acre and performance data, Woodford County, Kentucky, 1958.

	Yield	Lodging 1/ 7/2	Recovery 2/ 7/29	Recovery 2/ 8/12	Disease 9/16
Greenleaf	2.15	1	3.0	2.7	6.5
Stoneville Sel.	1.33	1	7.0	9.0	3.0
Tift	2.33	5	3.0	3.0	5.5
Georgia 337	1.88	7	3.0	4.5	3.5
Piper	2.44	3	1.0	1.0	5.5
Common	2.16	5	5.0	5.0	6.5
Stoneville Syn 1	1.49	1	7.0	7.0	3.5
Lahoma	1.83	3	4.5	3.0	8.5
Sweet 372 (S-1)	1.93	3	4.0	3.5	9.0
DeKalb 229 x 1136	2.11	5	7.0	5.0	3.0
DeKalb 3113 x 1136	2.02	3	7.0	5.0	4.5
L.S.D. .05	0.32				
.01	0.41				
C.V. %	6.2				

1/ Rating of 1 = least to 9 = most.
2/ Rating of 1 = best to 9 = poorest.
Seeded in 7" rows June 16

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MISSISSIPPI (USDA)

Rust Ratings Versus Juice Quality of Sweet Sorghums in South Louisiana, 1956

O. H. Coleman and Jack L. Dean (Meridian)

Diseases affecting the leaves of sweet sorghums, Sorghum vulgare Pers., have a detrimental effect upon the amount of sugars accumulated in the stalks, as has been known for some time. In 1956, conditions were favorable for a comparison of the quality of juice of 74 sweet sorghum varieties at Meridian, Mississippi, under rust-free conditions, and at Houma, Louisiana, under conditions of heavy rust infection. This is a report of that study.

The study involved four tests, two at Meridian and two at Houma. The Mer. nurseries comprised 25 varieties in 1/200-acre plots at Meridian and in 1/550-acre plots at Houma. The breeding nurseries comprised 49 varieties

in 1/1000-acre plots at Meridian, and in 1/550-acre plots at Houma. Both Meridian tests were on Ochlockonee sandy loam soil, and the Houma tests were on mixed soil. Each of the four tests had three replications of each variety.

Ten-stalk samples were used for juice analyses in all tests except in the Mer. nursery at Meridian, where 15 stalks were usually selected from each plot to supply enough extra juice for sirup tests. The stalks were milled the day they were harvested or the following day, except in the Mer. nursery at Meridian where they were left in storage for about a week so that the sirup quality might be compared with that in other tests. Brix readings were made with a Brix hydrometer. The Brix hydrometer indicates the percent of total soluble solids in the juice, most of which is sucrose and invert sugars. The plants were harvested in the ripe stage for sugar evaluation except in the Mer. nursery at Meridian where the plants were harvested in the dough stage, known to be optimum for sirup production. Rust ratings ranged from 0 (no infection) to 4 (most of the leaves heavily infected).

Other diseases and environmental conditions influenced the sugar content of the stalks in Louisiana, but rust appeared to be the most important disease. Zonate leaf spot was the only other disease prevalent, but it was rather sporadic in distribution. Some difficulty was experienced in determining the true stage of maturity of the plants at Houma because of bird damage to the seed.

Table 1 shows the correlation coefficients between rust ratings and Brix values at Houma in percent of the Brix at Meridian. A high negative correlation between rust ratings and Brix readings is apparent. Quadratic correlations fit the population no better than linear correlations.

Table 1. Correlations between rust ratings (x) and brix at Houma in percent (y) of the brix at Meridian for 74 sweet sorghum varieties, 1956.

Nursery	No. varieties	r_{xy}	b
Mer.	25	-0.5446**	-5.90
Breeding	49	-0.5108**	-3.73

**1 percent level of significance.

A breakdown of the information previously discussed is summarized in table 2 according to rust ratings. It is apparent that factors other than

rust reduced the total sugar content of the juice at Houma 19 percent below that at Meridian. However, the total loss of sugar at Houma for varieties, with a "4" rating was 37.6 percent when compared to the same varieties at Meridian. This was approximately twice the loss due to other conditions, indicating that the loss in quality due to rust was as great as that due to all other conditions combined. When varieties with "0" rust ratings at Houma were compared with those with varying degrees of rust infection, it was apparent that there was a gradual increase in the loss of sugars in the stalk associated with rust ratings. In fact, the varieties badly infected with rust were 22.8 percent lower in Brix than those with "0" ratings although the difference in Brix between the rust-rating classes at Meridian was within sampling error. On the average, if there was a trace of rust found on a variety, the accompanying loss was about 9 percent; however, if rust infection was heavy, the average loss was more than 20 percent.

Table 2. Rust ratings and juice quality of 74 sweet sorghum varieties grown at Meridian, Miss., and Houma, La., in 1956.

Rust rating at Houma	Number of varieties	Average brix Meridian	Average brix Houma	Brix at Houma in % of Meridian	Loss due to rust at Houma
				%	%
0	15	19.3	15.6	80.8	0
1	3	18.2	13.4	73.6	8.9
2	9	18.2	13.3	73.0	9.7
3	19	18.6	13.2	71.0	12.1
4	28	18.6	11.6	62.4	22.8

Two conclusions can be drawn from the data presented: (1) the loss of sugar in the stalks of sorgo is directly proportional to the severity of the rust infection, and (2) under conditions of severe rust infection, there was an average loss of approximately 20 to 25 percent of the sugar in the juice.

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MISSOURI

E. L. Pinnell (Columbia)

1. General Information -- Closed and open pedigree hybrids of grain sorghum were compared in 1958 Missouri trials at three locations. Twenty-nine commercial hybrids were entered from a total of nine companies. Trials will be conducted at five locations in 1959.

Grain sorghum acreage in Missouri increased by 130,000 acres in 1958 in spite of the disastrous harvest season of 1957. The 1958 acreage of 720,000 gave an estimated yield of 52.0 bushels per acre. With corn acreage controls off in 1959 the grain sorghum acreage may decline somewhat. Record corn yields of 1959 are fresh in the minds of farmers and comparative observation trials over the state indicate that corn outyielded sorghum except on land not too well fertilized.

2. The effect of dates and rates of planting upon certain agronomic character of grain sorghum varieties -- Abstract by Humberto Castro and E. L. Pinnell.

RS 610 and Westland were planted on May 2, May 16, June 13, June 27, and July 14. Plants were thinned to 4, 5, 6, 8, and 12 inch spacings within 36-inch rows. May plantings yielded much the same and were higher in yield than the two June plantings. Condensed data are as follows:

	Bushels per acre		
Space	May	June	July
4 in.	82	77	37
5 in.	81	72	25
6 in.	84	63	27
8 in.	68	58	20
12 in.	66	51	22
Av.	76	64	26

A supplementary study was made on attempting to determine how soon sorghum grain matures after blooming. Samples for computing dry weight accumulation curves were taken at 20, 25, 30, 35, and 40 days after blooming in each of four dates of planting (July date excepted). May plantings appeared to reach maximum dry weight 35 days after mid-bloom while June plantings required 40 days. The difference appears related to the temperatures prevailing during seed maturation.

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NEBRASKA and USDA

Report of Sorghum Investigations in Nebraska

O. J. Webster (Lincoln)

The harvested acreage of grain sorghum in Nebraska in 1958 was 1,686,000. This figure is 300,000 acres below 1957 but still five times the average for the 10-year period of 1947-56. The percentage planted to hybrids increased from 34 in 1957 to about 50 in 1958. The average yield of grain sorghums for the State was 50 bushels, an all time high.

Seed of five grain and one forage hybrids was produced under certification in 1958. There were 19 percent fewer growers of certified hybrids in Nebraska in 1958 as compared with 1957, but the acreage was reduced by only 5 percent. A crop of approximately 6,800,000 pounds of seed was produced but as in 1957, a part of the crop was damaged by an early frost, September 30.

The Lincoln project was planted under favorable conditions, and good stands were obtained. By the middle of June the seedlings turned purplish in color, and growth was arrested. The primary roots were discolored and died about as soon as they developed. Isolates from the roots by the Plant Pathology Department indicated the presence of a *Pythium* sp. and a *Fusarium* sp. Isolates of these organisms proved to be highly pathogenic on sorghums in greenhouse tests. This type of seedling rot has never been observed at Lincoln, and the cool soil temperatures were no doubt the contributing factor. The presence of this disease was general over the entire field, but it was definitely more severe in clearly delineated areas. The forage tests were not harvested, and the value of the yields of some of the tests of grain types is questionable.

Mean temperatures at Lincoln for June, July, and August were 5.0, 7.6, and 2.2 degrees below normal, respectively. The precipitation received during July was 12.46 inches, a record for the month. The precipitation for June and August were below normal. There was very little rainfall during October which permitted the crop to be harvested in good condition with practically no lodging.

A brief summary of a few studies in progress are given.

Genetic and cytogenetic studies

Juan Munoz completed the requirements for his Master's Degree in January, 1959. Mr. Munoz is employed by the Rockefeller Foundation as an assistant project leader for sorghum investigations in Mexico. For his thesis problem he studied the mode of inheritance of 14 mature plant characters and the linkage relation of the genes for several combinations

of these characters. A linkage was found between the genes for the character pairs, normal vs. bloomless and non-waxy vs. waxy endosperm, and the genes for normal vs. tan plant color and normal vs. liguleless.

Mr. Munoz also collected additional information on five reciprocal translocations isolated from seed of the varieties Cody, Western Blackhull, and Double Dwarf Yellow Sooner that had been irradiated with x-ray. The pollen abortion and floret sterility for an F_1 plant resulting from a cross between a translocation and normal plant approached the theoretically expected 66 percent.

Optimum plot size for grain sorghums

The increase in land requirements for adequately testing numerous sorghum hybrids has created a problem for many experiment stations. If land is available it is desirable to increase plot size sc that harvesting can be accomplished with a combine. In most instances harvesting must be done by hand and the prime question is, "How few plants are required per plot for a reliable test?"

In 1957, RS 590, RS 610, and Martin were planted in 4-row plots, 20 feet in length, and replicated four times. In each replication the plants in three adjacent plots that included the three varieties were thinned to a spacing of 6 inches and another three plots were thinned to 12 inches. Each plant in the area was harvested individually. For the analysis, units of 5 feet in length were arranged end to end in each row. Each row was made up of 4 units, each plot 16, and each replication 96.

The analysis of variance indicated a significant difference in the yield of the three varieties at the five percent level and that there was a non-significant interaction between varieties and spacings. The average yield from the plots spaced at 6 inches was 28 percent higher than that of the plots spaced at 12 inches. If small plots with a few plants are used for yield determinations, it is essential that stand be nearly perfect. This requires hand thinning, and it is much easier to get stands of 12 inches between plants than 6. These data would indicate that although yields are depressed in favorable seasons by a 12-inch spacing that the relative yields of varieties of the type included in this test would be the same as when spaced at 6 inches.

The coefficients of variability for plots of different sizes based on 5-foot units were determined.

No. of units per plot	C. V.
96	0.36
48	0.56
16	1.23
4	4.03
2	7.44
1	14.36

An estimate of soil heterogeneity was determined as b = -0.61. The cost of different operations in conducting the experimental yield trials of grain sorghums was estimated and the optimum number of units (single units were 5 feet in length) for a plot was determined to be from 2 to 4.

The analysis of these data was made by Juan Munoz.

This test was again planted in 1958 but abandoned because of a seedling disease.

Antherless male-sterile lines

The florets of plants of cytoplasmic male-sterile plants have rudimentary anthers. Under some conditions pollen may be shed by these anthers. A head which was completely antherless was found in a sterile line of 385. For the past two years numerous pollinations on these plants have been made using pollen from plants in different B lines. To-date, when such a pollination is made, the seed produced when planted will give plants which are antherless sterile and the sterile with rudimentary anthers in a ratio of about 1:1. If a completely antherless line could be developed there would be no problem in possible pollen shed. Seed set on these antherless plants has appeared to be poorer. Seed weights from several heads of both types selected at random gave proof that this was a valid observation.

Seed development studies

The germination, dry matter, and weight of seed harvested at regular intervals following the pollination of cytoplasmic male-sterile heads of 385 has been determined over a four-year period. Sterile line 7301 was included in this study in 1958. In the studies conducted prior to 1958 the dry matter in the seed reached its maximum at about 26 days following pollination. At this time the moisture content of the seed was 40 to 50 percent. The seed germinated 70 percent or better at 14 to 16 days.

The data obtained in 1958 deviated to some degree from the tests conducted previously. This may have been due to an abnormally cool period for a few days following pollination. The dry weight of seed of 385 leveled off at 27 to 29 days but continued an upward trend even at 43 days. The development of the seed was retarded during the first few days following pollination. A dry matter of 50 percent was reached between 29 and 34 days. The seed germinated 70 percent or better in 19 days. The dry weight of seed from 7301 plants reached a maximum at 36 to 38 days at which time the moisture content was 40 percent. The seed germinated over 80 percent at 17 days.

<u>Yield trials comparing A lines 385 and 3197 in hybrids RS 610, RS 650, and Texas 660, and A lines 7301 and 398 in hybrid RS 608</u>

The A lines of 385 and 3197, from Nebraska and Texas, respectively, were pollinated with 7078, Plainsman, and Caprock. Seed of these hybrids was planted in tests with five replications and at four locations in 1958. Seed of RS 608 produced in Nebraska and Texas was also planted in these tests. The A lines used to produce RS 608 are designated in Nebraska under lot number 7301 and 398 in Texas. No significant differences could be detected in the hybrids produced from the A lines of the two states.

Pre-emergence Weed Control in Sorghum

J. D. Furrer (Lincoln)

There continues to be a great deal of interest in pre-emergence weed control in sorghum. Numerous tests have shown that Randox is the most satisfactory material available when it comes to fairly effective weed control and safety to the sorghum crop.

In 1958 in cooperation with Monsanto Chemical Company, 45 cooperators received a gallon of Randox for on-the-farm pre-emergence trials. Cooperators were requested to fill out an evaluation sheet after using and observing the results with Randox. Twenty-seven evaluation sheets were returned, fourteen evaluating Randox on sorghum. Below is a summary of the cooperators' evaluations of Randox on sorghum:

(1) Six farmers used band treatments (12" to 13" bands) applying 1 1/3 quarts Randox per acre; eight broadcast sprayed using approximately four quarts per acre.

(2) Twelve cooperators reported good control of grassy weeds, one reported no control, and one failed to indicate the control obtained. Eight indicated fair to good control of pigweed. Wild buckwheat, ragweed, dock, smartweed, ground cherry, white weed, and pigweed were the principal weeds not controlled. The length of effective weed control averaged approximately 3 weeks.

(3) Ten of the fourteen sorghum seed producers plan to continue to use Randox. Four thought the material too costly. Two operators made comments on discomforts which they experienced during application. All reported that their fields showed some improved appearance as the result of using Randox.

For 1959 Randox is being formulated as 20% granules as well as liquid for spray applications. Some of the advantages claimed for granules:

a. Skin and eye irritation to the user is reduced.

b. No mixing or water hauling is required. Time is saved in addition to the product being more convenient.

c. Wind drift problems are reduced.

d. Volatility is reduced. The granules may last longer in the soil during dry, hot conditions.

e. Field tests show granules are up to 25% more effective.

f. Less weight to handle.

The Effect of 2,4-D on Ten Varieties of Grain Sorghum

Paul Sand (Lincoln)

Ten varieties of sorghum were treated with 2,4-D at three stages of growth for two years at Lincoln, and North Platte, Nebraska. Results show that some varieties are more resistant to 2,4-D than others. Yields were not always decreased by application of 1/3 and 1 lb./A. of 2,4-D at the three and twelve inch stages of growth, but yields of all varieties were decreased in all tests at the flowering stage. However, some of the decreases in yield at the three and twelve inch stages of growth were as great as some of the largest decreases obtained at the flowering stage. The most resistant variety was Martin and the most susceptible variety N-36. RS 610, Reliance, and RS 501 followed N-36 in susceptibility to 2,4-D, while RS 590, RS 650, RS 608, N-39 and Texas 620 fell between Martin and RS 610, Reliance and RS 501.

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NEW MEXICO

Sorghum Production

Charles E. Cypert (Clovis)

New Mexico farmers produced 8,085,000 bushels of grain sorghum in 1958, 23 percent more than in 1957 despite a 9 percent reduction in acreage. Yield per acre is estimated at a record high of 33 bushels compared with 24.5 bushels last year and an average of 14.5 bushels.

In experiments conducted at the Plains Substation under dryland conditions, the earlier varieties of grain sorghum have been most productive. The leading hybrids have been RS 610 and Tx 620, and the highest

yielding varieties have been Midland, Redbine-60, and Combine 7078. However, for the 3 year period, 1955-57, tests on irrigated land have had quite different results. For this period the highest yielding hybrids have been Tx 660, RS 650, Tx 620, and RS 610 in that order. Generally hybrids have shown a 10-15 percent advantage in yield over varieties under dryland conditions.

Forage sorghum tests have also pointed out the advantages of hybrids, especially in percent stand under dryland conditions. Leading varieties in 1958 yield tests were Beefbuilder, Silo King, NK-320, and Sourless with yields of 7.7, 7.4, 6.9, and 6.4 tons of air-dry forage per acre, respectively.

In broomcorn variety trials over a period of 3 years, 1956-58, the leading varieties have been Scarborough #7, Rennels #11, and Millers #8 with average yields of salable brush of 413, 384, and 338 pounds per acre, respectively.

Sorghum Improvement

Ronald W. Livers (Clovis)

Sorghum research in New Mexico is being carried on primarily at the Plains Substation 14 miles north of Clovis. However, the other four substations in the state at Tucumcari, Artesia, Los Lunas and Espanola are all doing some sorghum variety testing.

Research on sorghum at Clovis has been conducted under dryland conditions since the Plains Substation was started in 1949. John Carter, superintendent of the new station had charge of grain and forage sorghum testing until his death May 6, 1958.

We are developing a sorghum improvement project here which brings together the abilities of a plant pathologist, an entomologist, an agronomist and a plant breeder in the task of developing and evaluating new and better sorghum strains and hybrids for our area. At the present stage of breeding work a large number of very nearly homozygous lines are available for evaluation as varieties or parents of new hybrids. These lines are descendants of the best performing old-time kafirs and milos tested for many years in northeastern New Mexico. Crossing and selection has been carried on to bring good harvesting characteristics with regard to height, standability, exsertion, dry headstems and threshability into the end products. The result is a number of lines of diverse parentage which are quite similar phenotypically. The majority of these lines are somewhat earlier in maturity than Martin.

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OKLAHOMA and USDA

Sorghum Research and Testing

J. B. Sieglinger, F. F. Davies, C. E. Denman,
and D. E. Weibel (Stillwater)

Grain sorghum production in Oklahoma in 1958 was the largest on record being $18\frac{1}{2}$ million bushels and nearly double the 10-year average. This crop was harvested from 710 thousand acres which was 13 percent less than 1957. The increase in production was accounted for by a yield per acre of 26 bushels compared to the 10-year average of 13.4 bushels.

Over the years chinch bugs have been a periodic pest of sorghums in central and eastern Oklahoma, but in 1958 chinch bugs were only one of four insects bothering the crop. Seedlings were attacked by the flea beetle necessitating replanting of fields and experimental material. Chinch bugs were prevalent and severe all season. The sorghum midge became numerous on all the experimental plantings. Due to a wet season the crop was sown late and matured late. This allowed a build up of midge so that the yield tests were destroyed as well as most of the open heads in the breeding nursery. Only under treated bags was there good seed set. Selection was largely confined to bagged heads. In addition the sorghum headworm appeared on the late crop and caused some damage to the filling grain.

Grain sorghum improvement began in Oklahoma in 1915 when John B. Sieglinger was assigned to the project at the Southern Great Plains Field Station, Woodward, Oklahoma. The varieties Sooner Milo, Wheatland, Beaver, Day, and Pigmy were developed by him and released from the Woodward station. Fultip broomcorn, also, was developed at Woodward. Mr. Sieglinger moved to Stillwater in 1941 where he organized testing and breeding procedures for the development of grain and forage sorghum varieties for central and eastern Oklahoma with the assistance of Frank Davies beginning the same year. Robert A. Hunter was employed at Woodward in 1945 to assist with the program there. From Stillwater the grain varieties Dwarf Kafir 44-14, Redlan, and Darset have been released. Charles Denman became responsible for the sudangrass improvement in 1952. Dale Weibel joined the staff on sorghum breeding in 1958.

At the present time the Oklahoma breeding programs include the development of grain sorghum varieties, grain sorghum hybrids, forage sorghum varieties, forage sorghum hybrids, sirup varieties, sudangrass varieties, sudangrass hybrids, and broomcorn.

Nine hybrid sorghum performance tests with 35 hybrid entries from commercial companies and experiment stations plus check varieties were sown in central and western Oklahoma in 1958. Six were harvested. The results of these tests provided the basis from which the State Department of Agriculture issued permits to companies for seed sales in the state as they have the two previous years.

Based on the results of three years of testing in the above manner, eight hybrids are recommended for planting in Oklahoma in 1959. These are RS 610, RS 650, Texas 601, Texas 611, Texas 620, Texas 660, DeKalb E56a, and DeKalb F62a. All of these hybrids are recommended for the major sorghum area, and the DeKalb hybrids are recommended, also, in the central and eastern sections of the state where the environmental hazards of grain weathering, insects, diseases, and birds are major problems. Growers are cautioned that stalk weakness, and lodging may occur when these hybrids are subjected to soil moisture stress during the grain filling and maturing period.

In five hybrid forage performance tests seven hybrid entries from commercial companies were compared with the recommended varieties. As with the grain test the results from this test are used by the State Department of Agriculture as a basis from which to issue permits for seed sales in the state of qualifying hybrids. No hybrid forages are recommended in the state.

Additional lines of research conducted in Oklahoma are listed below:

1. Desiccating materials are being evaluated to determine their value in allowing earlier harvest.

2. Tha quality of hybrid forage sorghums is being compared to the recommended varieties.

3. Fertility experiments are being conducted at 10 locations in the state by J. Q. Lynd and B. B. Tucker.

4. Weed control chemicals are being evaluated by W. C. Elder.

5. Studies on charcoal rot and anthracnose are being continued in the Botany and Plant Pathology Department by H. C. Young and B. L. Keeling.

6. In the same department studies of the interrelationships of the many species of the genera <u>Sorghum</u> by F. P. Celarier are progressing.

7. Also in this department cytological studies of chromosomes and morphogenesis are underway by M. H. Brooks.

8. Feeding trials with sorghum grain are in progress in the Animal Husbandry and Poultry Departments by J. C. Hillier and R. H. Thayer, respectively.

9. In connection with the above the analysis of sorghum grain for amino acids has baen undertaken by R. J. Sirny in the Biochemistry Department.

10. Analyses of yellow endosperm strains and hybrids for carotenoid pigments are being completed in the same department by J. E. Webster.

11. Also in this department methods of determining tannin have been developed and the analysis of sorghum grain for tannin has been initiated by D. C. Abbott.

12. The mechanics of irrigation are receiving attention in the Agricultural Engineering Department by J. E. Garton.

Sorghum Cytotaxonomy and Cytogenetics

R. P. Celarier (Stillwater)

During the past several years, as a part of our forage improvement program, several studies have been initiated dealing with the genus Sorghum and its relatives. Generally this work can be divided into three categories, (1) Introductions, (2) Cytotaxonomy of the Sorgheae, and (3) Cytogenetics. This report is an attempt to briefly summarize these studies.

1. Introductions - Although foreign introductions of the genus Sorghum are numerous and have been given serious consideration by several workers, there is still a good prospect that this is the most neglected aspect of Sorghum improvement programs.

In our program much consideration has been given to introductions and slightly more than 500 accessions have been collected. Most of these have been grown at one time or another but they have never all been grown together. They have been extremely valuable to our program in many ways but because of lack of facilities their maximum value has not been realized.

Probably the biggest problem is securing good seed increases. Many Sorghum accessions, especially those from poorly collected Southeast Asia, require short photoperiods for flowering and consequently will not set seed under our conditions. Even many that do flower in Stillwater are so late that seed are not matured at the time of our first killing freeze. We are attempting to handle a few in the greenhouse, but this is far from satisfactory.

2. Cytotaxonomy of the Sorgheae - The subtribe Sorgheae is generally recognized as consisting of eight or nine genera. They are considered to be closely related to elements in the subtribe Bothriochloeae and are thought by some to have been derived from that subtribe. A really thorough study of the entire subtribe has not yet been made. I have attempted to summarize and review this subtribe in two reports (Celarier, 1958, Celarier, in press). Briefly this may be summarized as follows.

(a) Three of the eight genera are monotypic, two with very restricted distributions; whereas, the third, Rhaphis, is widespread in the Pacific. All genera are found in the Old World tropics but only one, Sorghastrum, has species definitely known to be endemic in the New World. Most genera are small but two, Sorghum and Chrysopogon, have more than twenty described species.

(b) The morphological similarities in the different genera strongly suggest certain paths of relationship. In general there seem to be two primary phylogenetic lines of relationship but there are suggestions of interconnections between these lines at several points.

(c) The cytological evidence indicates five as the basic chromosome number for the subtribe (Garber, 1950; Celarier, 1956), and all of the species studied, except Cleistachne sorghoides, are multiples of five. Polyploidy is common and, except for Para- and Stipo-Sorghums, allopolyploidy is suggested.

(d) Within the genus Sorghum many problems of relationship exist. Although this genus has been studied by many workers there are still no undisputed answers for such questions as; What are the relationships of the subgenera to one another? of Halepensia to Arundinacea? of Spontanea to Sativa? of Snowden's subseries to one another? the extent to which genes can be exchanged between the various taxa? and many others.

To the author it seems that answers to these questions should be of paramount concern to Sorghum breeding.

3. Cytogenetics - In general, it has been found that chromosome behavior at meiosis is extremely regular in all Sorghum species except the polyploids of the sub-section Halepense and the subgenera Parasorghum and Stiposorghum. This has also been true for all interspecific hybrids studied at this station. However, during the past year four accessions were encountered that had a rather high frequency of irregularities. In most it was not possible to identify these accessions as to species, but there was no difficulty in deciding the subgenera involved. The following is a brief account of the chromosome behavior of these accessions.

(a) Eu-sorghum - In this subgenus two accessions had irregularities. Morphologically both were suggestive of species hybridization, and both were 2n = 20. Also occasional irregularities were seen in an accession of S. subglabrescens but only a few cells were studied.

One accession (A-6130 from East Africa) was found to have from two to six univalents at metaphase I and cells with ten bivalents were uncommon. At anaphase and telophase I over half of the cells had lagging chromosomes and they were always dividing.

The second accession (A-7091, origin unknown) was much more regular than the first. Approximately 25% of the cells had two univalents at metaphase I and all other cells were normal. Two lagging chromosomes, usually dividing, were found in about 25% of the cells at anaphase and telophase I.

(b) Para-sorghum - In this subgenus two diploid ($2\underline{n} = 10$) accessions had irregularities.

One accession (A-4877 from Northern Rhodesia) was morphologically very similar to S. versicolor. It had an extremely high frequency (75%) of cells with two univalents at diakinesis and metaphase I. Although only a few cells were studied at anaphase and early telophase I, all had two lagging chromosomes in various stages of division. In some cells at late telophase there were no lagging chromosomes but they always had four chromosomes + two chromatids at each of the poles. Occasionally micronuclei were found in the dyad spore stage but they were rare.

In one accession of S. nitidium (A-6100 from the Ryukyu Islands) a plant was found that was desynaptic. This desynapsis was not complete and the plant was found to have an average of 4.5 bivalents per cell at pachytene, 2.82 bivalents at diplotene, 2.22 bivalents at diakinesis, and 2.00 bivalents at metaphase I.

This study was undertaken with the collaboration of K. L. Mehra and is now in press. (Celarier and Mehra, in press).

(c) Chromosome morphology of the Para and Stipo-Sorghums - For some time it has been recognized that the pachytene chromosomes of the Para and Stipo-Sorghums were quite different from one another in general behavior but no serious attempts have been made to identify the individual chromosomes of a particular species. Such a study was initiated last year with the assistance of R. L. Paliwal. Sorghum intrans and S. plumosum were selected as representatives of the Stipo-Sorghums and S. purpureo-sericeum, S. versicolor, and S. nitidium of the Para-Sorghums.

Although the results are not yet complete, certain general conclusions may be made. Three major conditions have been found as follows:

(1) Para-Sorghums - The generally recognized Para condition of pachytene chromosomes (i.e. - long entangled chromosomes, diffuse staining, etc.) was found in both S. versicolor and S. purpureo-sericeum. In these species it was not possible to identify any of the individual chromosomes.

(2) Stipo-Sorghums - The chromosomes in S. intrans were found to be very distinct and easily separated at pachytene. All five pairs of chromosomes have definite heterochromatic regions and two pairs have nucleoli. Although the nucleoli are intercalary for both chromosomes, one is very near the heterochromatic band; whereas the other is much further away.

In the remaining three chromosome pairs it seems possible to separate each of them by lengths of the light staining arms in reference to the heterochromatic bands.

(3) S. nitidium - Although this species is generally regarded as a Para-Sorghum, the contraction, staining, and spreading of the pachytene chromosomes is much more like that of the Stipo-Sorghums.

Heterochromatic bands are found in all five chromosome pairs, but two of these bands are terminal, one with and one without a nucleolus. One of the remaining three chromosome pairs is much shorter than the others and is easily separated. The other two are very similar in appearance and their separation is not yet certain; however, there does seem to be a secondary constriction in one but not in the other.

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The Insect Situation in Oklahoma

C. F. Henderson, E. A. Wood, Jr., and E. G. Thompson (Stillwater)

Sorghum insects caused more damage than usual in Oklahoma during 1958, and two species were of economic importance in this area for the first time in many years. The high precipitation during the past two years and the late planting of the sorghum crop were apparently responsible for this condition.

Flea beetle (Chaetocnema pulicaria)

The flea beetle caused widespread damage to young plantings of sorghum and broomcorn, and several fields in Garvin, Payne and Kingfisher Counties had to be replanted. In many fields there were 10-15 beetles per small seedling, and the leaves soon became dry and the plants died. This insect has not been reported as an economic pest of sorghum in this state for many years, and the high precipitation during the past two years is thought to have been responsible for the present outbreak.

Tests in Oklahoma with 17 different insecticides in 327 field plots indicated that the best control was given by the following materials at the indicated rates of application in pounds actual toxicant per acre: dieldrin 0.33-0.5, Shell 4402 0.33-0.5, Thiodan 0.5-1.0, toxaphene 2.0, heptachlor 0.5, Sevin 1.0, endrin 0.33, and aldrin 0.6. However, when applied on an equal cost basis, aldrin was equal to dieldrin, Shell 4402, and toxaphene in effectiveness.

Corn earworm (Heliothis zea)

Tests were also conducted to determine the effectiveness of several new insecticides for controlling the corn earworm in sorghum heads. The following materials gave the best control at the indicated dosages: DDT 1.5-3.0, endrin 0.5, Sevin 1.0, and phosdrin 0.5. When applied at the indicated rates as a broadcast treatment to simulate airplane application, none of the treatments were very satisfactory.

Chinch bug (Blissus leucopterus)

The chinch bugs flew into the sorghum plantings while the plants were still in the young seedling stage, and severe damage was caused. Three treatments with dieldrin emulsion spray at 1/2 pound actual toxicant per acre failed to protect susceptible varieties of sorghum under these conditions. Seed treatments with Thimet and Di-syston at 1/2 pound per 100 pounds of seed also failed to protect both susceptible and tolerant varieties against this insect.

Sorghum midge (Contarinia sorghicola)

The sorghum midge caused considerable damage to late planted sorghum throughout the State during 1958. In some counties from 20 to 100% damage occurred in individual late planted fields. This insect had not been reported as damaging the crop in this area for many years, and the high humidity during the past two years is thought to have been responsible for the present outbreak.

Eight insecticides were applied as emulsion sprays in preliminary tests against this insect, and DDT at 1.5 pound per acre showed the best control.

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PENNSYLVANIA

Sorghum and Sudangrass in 1958

E. F. Sullivan, J. E. Baylor, and J. B. Washko (University Park)

Forage sorghum varietal tests

Sorgo hybrids and varieties gave favorable yields when contrasted to adapted hybrid corn in test plots in southeastern Pennsylvania but were inferior to corn in central Pennsylvania (table 1). Replicated demonstration plots showed sorgo to be similar to corn in dry matter production at 5 locations in southeastern Pennsylvania but somewhat less suitable than an adapted corn hybrid in northeastern Pennsylvania.

In the tests, corn was biased in favor of sorgo planting dates. Nevertheless, early frost injury and a short, cool growing season limits sorgo production of the higher yielding hybrids and varieties in central and northern Pennsylvania.

Forage sorghum culture tests

In southeastern Pennsylvania, forage sorghum is usually seeded about 2 weeks after the average corn planting time or drilled in with soybeans for ensilage after spring annuals are harvested. Several sorgos and corn varieties were seeded in a drilled research planting to determine the effect of the addition of soybeans vs. nitrogen fertilizer levels (0, 65, 130 and 260 lb. N per acre) on the yield and composition of forage. The addition of nitrogen fertilizer gave significantly higher yields for all varieties (with N only 4.93 tons vs. 2.36 tons D.M./A. with soybeans), with no significance indicated among the levels of nitrogen applied. In addition, soybeans depressed yields with or without nitrogen fertilizer. The varietal-fertilizer interaction was not significant. The following seeding rates per acre were used with and without soybeans: corn 60 lb., sorgo 30 lb., and soybeans (Wabash) 90 lb.

Also in 1958, a test was conducted at Centre Hall (Central Pa.) to determine the effect of wide row vs. narrow row spacings on the yield of sorgo and corn. It was found that the 1 ft. spacings gave 5.85 tons of dry matter yield, whereas, the 3.3 ft. spacings (plant population 52,320 for sorghum and 19,640 for corn per acre) yielded 4.90 tons of dry matter per acre. Plant population was 3.3 times higher under narrow row culture. Corn outyielded sorgo at both row spacings. The interaction was not significant.

Table 1. 1958 Sorghum adaptation test results at two locations in Pennsylvania, abridged. (Av. of 4 replications per location.)

Hybrid or 1/ variety	Central Pa.-Centre Hall Harvest date	Central Pa.-Centre Hall Percent lodging	Central Pa.-Centre Hall Tons/A. dry matter	Southeastern Pa.-Landisville Harvest date	Southeastern Pa.-Landisville Percent lodging	Southeastern Pa.-Landisville Tons/A. dry matter
RS 302 F Sorghum	10-7+	35.0	5.30	9-23	25.0	5.52
RS 303 F Sorghum	10-7+	15.0	5.44	9-25	10.0	4.92
Pa 602 (Corn)	10-5	0	7.65	9-5	5.0	5.75
Atlas Sorghum*	10-7+	10.0	5.54	9-30	0	5.75
Black Amber Sorghum*	9-19	35.0	4.03	8-31	25.0	4.41
Early Sumac Sorghum	10-7+	5.0	4.42	9-18	15.0	5.03
Hegari Sorghum	10-5	15.0	3.74	9-16	10.0	4.12
Sugar Drip Sorghum	10-7	--	--	10-5	0	7.76
L.S.D. Var. .05			0.99			0.48
C.V. %			13.5			6.1

1/ 18 entries not shown. Planting dates, June 4 (C) and May 28 (SE). Killing frost Oct. 5.

* Recommended in Pennsylvania.

\+ Did not reach ensilage maturity.

Sorghum population density 52,320 plants and corn 19,640 plants per acre in 40 inch rows.

Sudangrass varietal tests

A uniform sudangrass varietal test has been grown cooperatively with the U.S.D.A. in 1957 and 1958. In central Pennsylvania improved pearl millets, seeded at 25 lb. viable seed per acre, appear to be as well adapted as Piper sudangrass, drilled in 1 ft. spacings at 30 lb. of seed per acre, which yielded 3.09 tons dry matter per acre in 2 cuttings in 1958. However, at Landisville, Piper and Greenleaf sudangrass outyielded (3.55 tons D.M./A.) the millet entries (2.68 tons D.M./A.) which failed to recover after the first harvest. In Pennsylvania, sudangrass should be seeded about June 1-10 for grazing and July 1-10 for ensilage.

Grain sorghum varietal tests

Interest is being shown in grain sorghum as a possible replacement for corn as small game feed and cover in southern and south-central Pennsylvania. A preliminary yield evaluation study conducted in southeastern Pennsylvania in 1958 showed that some grain sorghums offer yield potential about equal to corn during favorable seasons (RS 610, 101 bu. and Pa 602 corn, 106 bu./A.). However, in central Pennsylvania Pa. 444 corn outyielded RS 501 sorghum by 62 bu. per acre. The grain yield was 103 bu. of 15.5% moisture shelled corn per acre. Even at southernmost locations, blackbird damage, early frost, and wet grain limits grain sorghum production. Winter standability, shattering, and game bird preference ratings will be taken.

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ROCKEFELLER FOUNDATION

Sorghum Improvement in Mexico

R. D. Osler and Elmer C. Johnson (Mexico City, Mexico)

The need for a crop which will yield better than corn under conditions of inadequate or poorly distributed rainfall has helped to bring about a rather rapid increase in the area planted to sorghum in Mexico during recent years. Another factor contributing to this increase has been the growing need for feed grains primarily for swine and poultry. At the present time all grain and forage sorghums grown in Mexico were introduced from the United States, and none have been found to be well adapted to the rather large area of Mexico which is normally deficient in rainfall and is above 6000 feet in altitude.

With materials and advice provided by R. E. Karper and J. R. Quinby a small grain sorghum breeding program was initiated in 1956 and 1957. A few of the objectives of this program are as follows:

(1) Because the commercially available grain sorghums are medium to late in maturity in Mexico, samples of the range of vegetative cycles within the Kafirs, Milos, Redbines, Hegaris and Shallus were obtained. These are being studied in an effort to select materials better suited to the high elevation areas of low rainfall.

(2) Incorporation of the large seed and high yield of certain Indian sorghums into the germplasm of the combine type sorghum. The Indian sorghums selected for this program look extremely good in certain areas of Mexico but are too tall. A backcross program was initiated using the Indian selections as recurrent parents and a quadruple dwarf strain provided by J. R. Quinby as the non-recurrent parent. At the same time the Indian selections were crossed to the cytoplasmic male sterile source H-3197 to determine the possible future use of combine height Indian sorghums in a hybrid program.

(3) Development of hybrid grain sorghums better adapted to the major sorghum production areas of Mexico. Following the development of hybrid sorghums in the United States considerable interest has also been noted in Mexico. Several of the grain sorghum hybrids produced by various experiment stations and commercial seed companies in the United States were yield tested in different regions of Mexico during the years 1956, 1957, and 1958. Data from these tests indicate that the hybrids presently available are no better than, if as good as, the best available commercial variety.

Sorghum Improvement in India[1]

Kenneth O. Rachie (New Delhi, India)

In India, sorghum is considered one of the millet group, which includes, besides sorghum, the "Great Millet," seven other species. Millets occupied 86.7 million acres in India in 1956-57, more than any other single crop. Sorghum, which is the country's most important rainfed cereal, was grown on 41.3 million acres or 17.2% of the area planted to food crops. Pearl millet (Pennisetum typhoides) occupied 27.5 million acres or 11.5% of the food crop acreage. Finger millet (Eleusine coracana) and Italian millet (Setaria italica) are also important in some areas.

Investigations on sorghum and the millets were started during the early years of this century by such Indian workers as Ayyangar, Ayyar, and Rao. The attention paid to practical breeding of the millets has never been commensurate with the importance of these crops in Indian agriculture, largely because the millets are not "prestige" crops like wheat and rice. Nevertheless, it is estimated that about 35% of the population

[1]Paper No. 109 of the Agricultural Journal Series of The Rockefeller Foundation.

is dependent on millet grain as the principal staple of their diet. Recently the Indian government has given greater attention to millet improvement in an attempt to make up the cereal grain deficiencies and meet the ever-increasing needs of the rapidly expanding population.

Factors affecting the production of sorghums in India

Climate and soil conditions are the principal factors affecting sorghum production in India. Sorghum is about 97% rainfed. Most of the rainfall is received during the monsoon, which usually starts the middle of June and reaches its peak in August. Another lesser peak occurs during October in some central and southern regions. North of latitude 20° sorghum is mostly grown as a kharif or summer crop, with plantings in June and July. In central and southern states, where average minimum temperatures do not drop below 50° F. and the monsoon extends through October, the rabi or cool season plantings are more predominant. Rabi sorghums are planted in late September and October and harvested in February. About 65% of the sorghum grown in Bombay is the cool season or rabi crop. A very limited amount of sorghum is planted under irrigation in February and harvested in May.

Soils are generally low in organic matter and other elements of fertility because for hundreds of years there has been complete removal of all plant residues without restoration of any kind. Even manure is often burned as a fuel for cooking purposes, although it is worth more as fertilizer.

Mixed cropping is a very common practice in India. Sorghum and legumes are most frequently planted together. Pigeon pea (Cajanus cajan), horse gram (Dolichos biflorus), and several species of Phaseolus are often planted in association. Four or five rows of sorghum to one row of the legume or cotton is the usual planting ratio. Italian millet may be planted between sorghum rows in areas of deficient and uncertain rainfall. In some years the rains may be insufficient to mature the higher-yielding sorghum, but the shorter duration Italian millet will usually make some grain.

Although sorghums may be planted in rows, broadcast seedings are very common. The seed rate is much higher when the crop is grown exclusively for fodder. Row spacings of 18 inches are generally preferred, but wider spacings of up to 3 feet may be used under drier conditions. Hand thinning, hand weeding, and two or three harrowings with a bullock-drawn harrow may be given during the growth of the crop. In general, very little fertilizer is applied to the sorghum crop except in the south, where it is a common practice to apply 2-5 tons of farmyard manure.

Harvesting is accomplished by cutting the heads or the entire plant. The harvested heads are threshed by being beaten with a stick or crushed

beneath a bullock-drawn stone roller. Yields averaged only about 403 pounds of grain and 1200-1500 pounds of straw per acre. Under favorable conditions, 700-1000 pounds of grain per acre are obtained.

Use of sorghums in India

Millet and sorghum grain is used almost exclusively for human consumption. It is either cracked and cooked as rice or ground into flour for unleavened flat bread. To a limited extent the grain may be used for parching or popping. The preparation of sirup from sorghum juice is not important since sugarcane products are widely available. Sorghum fodder is one of the major sources of feed for the 205 million head of domestic cattle and milk buffaloes in India. It is fed green or dried as hay. The making of silage has not been developed. The dried stalks of the millets and sorghums may be used for thatching purposes and sometimes for fuel.

Some aspects of sorghum improvement work in India

The breeding of sorghums for India is a highly complex problem. There is a wide variation in conditions and requirements throughout the sorghum-growing areas of the country. Plant improvement specialists claim positively that sorghum varieties in use are highly localized in adaptation. Certain improved varieties, such as Maldandi 35-1, are more cosmopolitan in nature and more widely grown than others. Even this variety, however, is restricted to cool season plantings in parts of Bombay, Mysore, and Andhra Pradesh. Response to day length is an important factor in the localizing of varietal adaptation. Kharif varieties will produce more grain during the rabi (winter) season but greater forage yields in summer. Rabi varieties, especially in Northern India, become very tall and extremely late if grown during the kharif or summer-monsoon season.

Indian varieties, improved and unimproved, are highly localized in distribution owing to the variable growing conditions and the lack of communication between agricultural regions. Many of the early improved varieties have been selected from locally adapted types. Later improvement by hybridization techniques has been the result of crossing rather closely related materials.

Indian sorghums, particularly unimproved varieties, may have very long maturation period, low yielding capacity, poor exsertion, and very compact heads. Varieties may have sweet, juicy or non-sweet, pithy stalks. Mixtures of juicy and pithy types may be found in farmers' fields. Thin-stalked varieties are preferred for their superior forage quality. Fine stalks, either dried or green, are more readily ingested by livestock. A rather undesirable characteristic of Indian sorghums is their habit of producing multiple heads from the upper nodes. As many as eight to ten small heads ripening unevenly from one stalk have been observed. This multiple-headedness seems to occur following late rains or lodging on moist soil and is explained as being the result of an accumulation of moisture inside the upper leaf sheaths near the node.

The Indian varieties are particularly well adapted to the variable conditions and cultural practices of Indian agriculture. They are tolerant of the poor fertility conditions that predominate throughout the country's cultivated lands. During the summer monsoon moisture conditions may be extremely wet or, if the rains are late and uncertain, very dry. Sorghum fields have been observed to be green and developing even after standing two or three months in one to two feet of water.

Grain quality of Indian sorghums is generally very good, since the grain is an important staple in the diet of a large number of Indians. Preferences vary from place to place. In some areas yellow, red, amber, or white grain color is preferred. Large, white, pearly kernel types are usually considered desirable. Chalky or soft starch varieties are less popular, but in some localities this quality would not be found objectionable. One of the types having exceptionally good cooking quality is identified as "H-1." This is a late variety which matures in about 135 days when planted in early October in Mysore State. It has a very compact head with medium sized grains white in color. It is preferred above all other varieties in this region and is reported to have the "sweetest" tasting grain. There are some opinions that compactness of head is related to taste quality. H-1 and similar varieties will be used as germ plasm sources for desirable grain qualities. The cooking quality of sorghum grain is a field that requires some intensive investigation before real progress can be made on grain quality improvement.

Of the multiplicity of pests attacking sorghums in India, insects are probably the most important. The sorghum stem borer, which is similar to the European corn borer, and a Diptera shoot borer are widespread and can cause almost complete loss of stand. Other insect pests include the Deccan Wingless Grasshopper, aphids, jassids, and several other insects which attack maturing heads. The plant parasite, Striga sp., smuts, seedling blights, rust, Helminthosporium, and anthracnose are further problems. Sugary disease, caused by Sabacelia sorghi, produces an anemic-looking plant and the collection of honey-like deposits on heads and leaves. Several of the native varieties show tolerance to some of these pests while exotic American varieties are usually susceptible. In preliminary observations, good tolerance or resistance to the sorghum borer, the sorghum fly, and Striga has been found. It will be necessary to incorporate this resistance into agronomically desirable types.

The development of hybrid sorghums is being studied. Some of the Indian x American m.s. kafirs give tremendous vigor but do not combine all the characteristics desired by Indian farmers. Eventually, more desirable male steriles will be evolved for the production of better hybrids. Commercial utlization of hybrid sorghums will be delayed until the Indian government or some other agency can foster the large-scale production and distribution of hybrid seed.

Insect Pests of Sorghum in India[1]

P. O. Richter and Kenneth O. Rachie (New Delhi, India)

Sorghum in India is attacked by a number of insect pests, but in the past entomologists have not considered them as serious as the pests of such crops as paddy, cotton, and groundnuts (Ramakrishna Ayyar, 1940). In varietal plantings observed by the writers in many parts of India during 1958, however, insect damage was found to be the major problem limiting production. About 95% of all experimental plantings at Delhi and about 80% of the plantings at Ajmer were destroyed in 1958.

Field experience to date and a search of the rather extensive Indian literature indicate that about 40 different insects and a few mites damage sorghum. Of these, about 10 are of major importance. Some of the principal insect and mite pests of sorghum in India are discussed in this paper.

1. The Sorghum Stem Borer (Chilo zonellus Swinhoe). The 1958 experimental plantings of sorghums at Delhi and Ajmer (Rajasthan) were heavily damaged by attacks of the sorghum stem borer. This pest resembles the European corn borer in the U.S.A. Its development and feeding habits are similar. Egg masses are laid on the underside of the leaves, from where the young larvae migrate to the stem and bore into the stalk. If the plant is young, the main shoot may be killed or heavily stunted. As a consequence secondary tillers are formed, which, if attacked in turn, may produce third and fourth tillers. The result is a tuft-like growth that may develop very late. A healthy, growing plant can tolerate several borers with few outward symptoms of damage, and some plants contain 25 or more borers. Yields may be reduced by later attack, but there is usually some production. In Northern India, these borers attack during the summer. Very little new infestation occurred after September 1, 1958. The insect also causes heavy damage to maize, but it prefers sorghums.

Methods for controlling the sorghum stem borer are still unsatisfactory. Cultural control methods, such as removing infected plants and adjusting planting dates, may be beneficial. Repeated applications of insecticides such as aldrin, endrin, BHC, and DDT have been tried on experimental plantings with varying success. The problem is to keep these chemicals on the plant and effective during the monsoon period when rains are heavy and frequent. Release of an egg parasite (Trichogramma evanescens minutum) has been recommended when Chilo eggs are abundant (Narayanan, 1953).

[1] Paper No. 108 of the Agricultural Journal Series of The Rockefeller Foundation.

2. The Sorghum Fly (Atherigonia indica Malloch). This small fly is widespread throughout India from Delhi to the Southern States and causes even more severe damage than the stem borer on late plantings. The female fly, about the size of a half-grown housefly, lays its eggs singly on the undersides of leaves of small sorghum plants in the two- to six-leaf stage. After hatching, the tiny maggot migrates into the young whorl and tunnels down one of the young leaf sheaths, then cuts through and severs the growing point of the plant. The dead shoot provides decayed matter upon which the maggot feeds. The young plant may be killed or may produce secondary tillers which can be attacked in turn. The effect is a tuft-like growth, very late and low-yielding. The plant is attacked only during the first five or six weeks of growth; after that time, the maggot is unable to cut through the growing shoot. At Coimbatore, life habits and resistance to the fly in some varieties and after five weeks of growth have been correlated with the deposition of silica (Ponnaiya, 1951).

Effective chemical control measures have not yet been developed. Rao and Rao (1956), using sprays of DDT or BHC applied at 10-day intervals, achieved fairly good control in one year but were less successful in later years. Date of planting would be an important method of control, where feasible, because this pest does not become serious until late summer. Another control measure is thinning at intervals of about two weeks. Sorghum is planted in hills 12 - 15 inches apart with rows spaced at 12 - 18 inches; 15 seeds are planted per hill in the form of a 6-inch diameter circle. During each subsequent thinning, the infested plants are removed and destroyed. This practice can be recommended commercially where hand labor is relatively inexpensive. In India an acre of sorghums can be thinned at a cost of only about \$0.80 - \$1.60 depending on locality.

3. Grasshoppers: The Deccan Wingless Grasshopper (Colemania sphenaroides Boliv.), the Surface Grasshopper (Chrotogonus trachypterus Blanch.), and "phadka" (Hieroglyphus nigrorepletus Bol.). These pests attack sorghums and millets, causing serious damage in certain years (Kadam and Patel, 1955, 1957; Puttarudriah, 1958; Narayanan, 1953). Their attack is sporadic, however. Use of BHC dusts or poison baits has been recommended for control.

4. The Katra Hairy Caterpillar (Amsacta albistriga M.). This caterpillar, which feeds voraciously on both sorghums and maize, is mentioned as a major pest by a number of Indian writers. The moths emerge and lay their eggs soon after the first monsoon showers (Ramakrishna Ayyar, 1940). For control, Kadam and Patel (1957) recommend use of sodium fluosilicate dust or poison baits containing 5% BHC or 5% DDT.

5. The Spider Mite (Oligonychus (Paratetranychus) indicus H.). This mite causes leaf reddening on both seedlings and older plants (Ramakrishna Ayyar, 1940). The mite is controlled to some extent by the predator (Stethorus pauperculus). Dusting with sulfur is recommended where heavy damage is expected.

6. Earhead pests: the Capsid Bug (Calcocoris angustatis Letch.) and the Cecidomyiid Fly Maggot (Contarinia andropogonia Felt). These insects are described by Puttarudriah (1958) as being the most serious pests of sorghum in some years in parts of Mysore State. They attack during the milk stage and cause chaffy heads.

7. Mature grain pests: the Webbing Caterpillar (Stenochroica elongella H.), the Castor Pod Borer (Dichocrocis punctiferalis Gvenee), and the Corn Earworm (Heliothis armigera Hubner). Of these, the webbing caterpillar is the most important (Puttarudriah, 1958). Heavy webbing of the heads is caused by the castor pod borer and the webbing caterpillar. Our observations at Hyderabad indicate that very looseheaded types appear more resistant to the webbing caterpillar than the semi-compact or semi-loose types. Dusting with 5% BHC and early harvesting of grain are recommended.

8. White Grubs (Schizonycha sp.). Plantings at Ajmer in 1958 suffered some damage from this pest. Uneven plant growth, sparse stands, and lodging because of damaged root systems are symptoms of grub attack.

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TEXAS and USDA

Sorghum Research Studies at College Station, Texas

Earl Gilmore (College Station)

Head smut

Head smut has become a serious problem in some areas of Texas during the last three or four years. The disease is particularly severe along the Gulf Coast in South Texas. A critical disease survey has not been made, but it has been estimated by personnel of Substation No. 1, Beeville, Texas, that infection during 1957 and 1958 was 5 - 10% in three counties near Corpus Christi, with some small areas having as high as 25 - 30% infection. Head smut has also increased in the Blacklands and High Plains of Texas. It is believed that growing of very susceptible varieties recently has caused the build up of the disease.

Field tests[1] in the Gulf Coast area during 1957 and 1958 showed differences among lines and hybrids for resistance to head smut. Data from a replicated test in South Texas during 1958 are shown in table 1. The interaction of varieties and replications was low. Data from one row observation plots are shown in table 2. Field tests for locating resistant breeding material seem to be promising, and an extensive screening program will be conducted in South Texas during 1959.

Miscellaneous studies

Growth rates of sorghum varieties grown under constant temperature and light conditions are being studied at College Station. The studies were begun in November 1958, and no data has been processed.

The increase of dry weight and decrease of percentage moisture of grain from seven varieties or hybrids were studied at College Station and Temple, Texas, during 1958. Four to five plants were sampled every other day from 10 days past blooming until the moisture percentage was 13%.

[1] Tests were conducted by Dr. Robert B. Stewart, Sam Houston State College, formerly Plant Physiology and Pathology Department, A & M College of Texas, in cooperation with Substation No. 1, Texas Agricultural Experiment Station, and Refugio County Agricultural Agent, D. F. Bredthauer.

The grain of Martin dried at a faster rate and reached its maximum dry weight before the other varieties or hybrids which were studied. This study will be continued for several seasons. All the data has not been processed, but table 3 shows a summary of results from College Station.

Five Texas corn hybrids and five sorghum hybrids or varieties were compared for four dates of planting at College Station during 1958. Yields in bushels per acre are shown in table 4. RS 610 had the highest average yield among the sorghum entries, and Texas 30 had the highest yield among the corn entries. Corn had a slightly higher average yield than sorghum for each date of planting.

Table 1. Percentage of sorghum head smut infection of varieties and hybrids in Refugio County, Texas, 1958.

Entry	Replication				Total no. plants counted	Total infected plants	Overall percentage infection
	I	II	III	IV			
Comb. Wh. Feterita	0.0	0.0	0.0	0.0	276	0	0.0
RS 630	0.0	0.0	0.0	0.0	419	0	0.0
Plainsman	0.8	1.2	6.5	0.7	553	11	2.0
Texas 620	4.7	5.1	3.2	2.2	648	25	3.9
Martin	2.4	6.6	1.0	4.2	515	20	3.9
RS 650	3.2	6.1	6.5	4.4	655	33	5.0
Texas 611	9.1	5.7	4.8	2.6	625	36	5.8
H 7308	5.4	6.9	5.0	8.8	339	23	6.8
Texas 601	7.0	9.4	5.2	8.2	741	54	7.3
Texas 660	7.7	10.6	7.4	5.0	572	44	7.7
C44a	9.4	6.7	9.3	5.8	588	45	7.7
C. Kafir (B3197)	5.1	10.5	13.7	7.7	622	56	9.0
RS 590	16.1	3.4	15.0	5.8	586	60	10.2
Texioca 54	9.6	12.6	12.3	7.4	528	55	10.4
Redbine 60	7.7	10.4	20.0	15.5	445	60	13.5
AMAK R-10	10.3	14.5	11.0	18.3	416	58	13.9
E56a	14.1	14.8	18.4	12.8	599	90	15.0
RS 610	21.3	12.0	19.0	19.0	420	75	17.9
7078	43.5	35.2	39.7	33.3	450	173	38.4
Combine Shallu	54.5	54.8	56.2	67.4	700	408	58.3

Table 2. Percentage sorghum head smut infection in varieties grown in observation plots in Refugio County, Texas, 1958.

Variety	No. plants counted	Percentage infection
Spur Feterita	82	0.0
D.D.Y. Milo	74	0.0
Combine Hegari	178	0.0
Caprock	123	0.0
Tx 09	62	0.0
Manchu Br. Kaoliang	120	0.0
Tx 07	125	0.8
Tx 04	160	1.2
Norghum	182	1.6
Redbine 66	146	2.1
Texas Blackhull Kafir	151	2.6
Edwards Wh. Combine	138	2.9
Resistant Wheatland	104	2.9
Kalo	117	3.4
Plainsman	111	3.6
Atlas	135	4.4
Redlan	120	5.8
Martin	143	6.3
Combine Kafir (B 3197)	126	7.9
Shantung Br. Kaoliang	76	7.9
Redbine 60	105	8.6
Chinese Amber	150	9.3
Orange (SA 20)	164	11.0
White African (FC 6604)	118	13.6
Straight neck (FC 13490)	115	13.0
Resistant Colby	124	16.1
Saccaline (FC 13498)	48	22.9
Texas 74	117	28.2
Schrock	116	35.3
Resistant Day	105	29.5
Combine 7078	71	56.3
Darso No. 28	83	91.5

Table 3. Average number of days from blooming to maximum dry weight of grain and percentage moisture of grain at maximum dry weight.

Variety	Days from blooming to max. dry weight	Percentage moisture at max. dry weight
Martin	25	33
Combine 7078	27	33
B 3048 (Redbine selection)	27	32
Plainsman	29	29

Table 4. Average yields of five corn hybrids and five sorghum hybrids or varieties planted on four different dates at College Station, Texas, 1958.

	Planting dates				
	March 7	March 21	April 17	May 22	Mean
Corn	Yield-bushels per acre				
Texas 30	58.0	66.8	77.0	50.7	63.1
Texas 28	53.0	62.9	72.5	57.2	61.4
Texas 36	50.2	64.9	63.2	46.2	56.1
Texas 34	41.2	65.9	65.9	38.4	52.8
Texas 38	46.8	50.4	58.5	26.5	45.6
Mean	49.8	62.2	67.4	43.8	55.8
Sorghum					
RS 610	61.7	55.6	76.2	54.7	62.0
E56a	53.0	55.6	74.4	53.0	59.0
Texas 660	56.0	43.4	68.7	49.9	54.5
Combine 7078	49.5	46.8	55.0	23.2*	43.6
Martin	54.3	34.2	47.7	28.0*	41.0
Mean	54.9	47.0	64.4	41.8	52.0

*Severely damaged by sorghum webworm.

Genetic Barrier in Sorghum vulgare x S. virgatum Crosses

A. Ghafoor Bhatti (College Station)

Sorghum virgatum has the same chromosome number (n = 10) as the grain sorghums and has been reported to readily hybridize with them yielding fertile F_1 hybrids. But it tillers profusely and has very thin stalks rarely exceeding .5 cm in thickness. The leaves are narrow, seldom over 1.5 cm in breadth. It has medium sized open panicles with deciduous spikelets like Johnson grass but is devoid of rhizomes. The caryopsis is slightly larger than that of Johnson grass and is completely covered by the long persistent glumes.

The existence of profound morphological differences between the grain sorghums and *S. virgatum* or other grass sorghums that freely interbreed with them, presented an interesting problem for cytotaxonomists. This study has been undertaken to investigate the nature of these differences by checking the linkage relationship of genes in *S. vulgare* x *S. virgatum* crosses, using the marker stocks of *S. vulgare*, and thereby ascertain whether the differences between the two species are genic or whether they involve some cryptic structural differences in the chromosomes.

The results so far indicate no difference in the linkage relationship of genes under study, except in the case of the ms_2 *a* v_{10} linkage group where significant reduction has been obtained between ms_2 and the *a* gene loci. The fertility of F_1 hybrids in this cross was also considerably impaired.

Study of the F_2 generation revealed that the dominance relationship of the gene *A* responsible for the awnless condition of the lemmas is also greatly modified by a set of minor genes that give polygenic segregation in the F_2 generation. Considerable reduction in the modifying effect was observed in the test cross progeny when *Sorghum vulgare* was used as the tester parent, which shows that most of the modifying factors are carried by *S. virgatum*.

A colchicine induced tetraploid obtained by doubling the chromosome number of the F_1 hybrid gave improved fertility, indicating that the parental species had accumulated sufficient genetic differences to yield a segmental allotetraploid. But in order to achieve this end, some sort of genetic barrier seems to be a necessary prelude.

A clue to this problem has fortunately been obtained. It was observed that the crosses between *S. virgatum* and two of the five genetic stocks of *S. vulgare* yielded hybrids which were not viable. The hybrid seeds either failed to germinate or the plants died in the seedling stage. The germination process was extremely slow. Radicals of the young seedlings died soon after germination. The plumules made very slow growth and

eventually died when the food reserve in the endosperm was exhausted. All efforts to raise the seedlings to maturity failed. The young embryos cultured in artificial media also failed to grow beyond the two-leaf stage. Adventitious roots did develop from the first nodes in some of the seedlings treated with root promoting hormones, but in spite of that the plants failed to make any further growth. Treatment with gibberellic acid also did not improve development. No difference in growth or development was observed in the seedlings resulting from the reciprocal crosses.

Success and failure of different genetic stocks of Sorghum vulgare to yield normal F_1 hybrids when crossed with Sorghum virgatum are given below:

Genetic stock	Linkage group	Success or failure of the cross with S. virgatum
I	ms_2 a v_{10}	success
II	d rs p	success
III	q^r b gs_1	failure
IV	R y v_{11}	failure
V	R y g_2	success

For the study of linkage relationship, check crosses were also made between all the marker stocks and a stock of Kaoliang which carries all the corresponding dominant alleles.

On the failure of crosses between marker stocks III and IV with Sorghum virgatum, it was decided to make an attempt to cross F_1 hybrids between these marker stocks and Kaoliang with S. virgatum. One hundred and seventy-eight seeds obtained from these crosses were planted during the summer of 1958, but none of them developed beyond the seedling stage. Kaoliang itself when checked, also failed to yield successful hybrids in crosses with S. virgatum.

In order to study the genetics of this barrier, crosses were made between Sorghum virgatum and the F hybrids obtained from crosses between Kaoliang and marker stocks II and V, which yielded normal hybrids when crossed with S. virgatum.

The results obtained are given as follows:

	Observed	Expected on 1:1	Chi-square	P
I Cross:				
(Stock V x Kaoliang) x S. virgatum				
Total number of seeds: 128				
normal	61	64		
abnormal	59			
not germinated	8	64	.28	.5
	128			
II Cross:				
(Stock II x Kaoliang) x S. virgatum				
Total number of seeds: 48				
normal	21	24		
abnormal	18			
not germinated	9	24	.75	7.25
	48			
Pooled results				
normal	82	88		
abnormal	77			
not germinated	17	88	.82	.25
	176			

This gave an indication of the presence of a single genetic factor causing a complete barrier to gene exchange between certain races of the two species.

Further studies on the behavior of this genetic factor in different cross combinations are being made.

Preliminary observations on the results of a cross between the two F_1 hybrids (Stock II x Kaoliang) x (Stock II x S. virgatum) gave a 3:1 ratio of viable and nonviable plants, which lends support to the hypothesis that a single genetic factor is involved in the crosses under study.

The Combining Ability of Certain A and R Lines at Chillicothe, Texas, 1957-1958

J. R. Quinby, J. C. Stephens and K. A. Lahr (Chillicothe)

The combining ability of seven A lines and eight R lines has been observed at Chillicothe for two years. Grain yields from the 1957 and 1958 Preliminary Hybrid Yield Tests are shown in table 1. Each yield figure shown is an average of six replications.

It appears that the three A line Combine kafirs used are quite similar in combining ability. Wheatland hybrids performed well in 1957 but poorly in 1958. Redlan has as good general combining ability as the Combine kafirs. Martin has lower general combining ability than the kafirs. The Redbine selection used has combining ability similar to that of Martin.

Combine 7078 and Combine White feterita have greater general combining ability than the other pollinators. It seems logical to assume that the various R lines rank from high to low about in the order in which they appear in the 1958 table.

Instances of specific combining ability in the data appear to be scarce.

Table 1. Preliminary hybrid yield test.

A line	R line Yield of grain, bushels per acre, 1957							
	7078	396	7000	7005	5507	5904	5874	Average
399	54	67	56	64	56	56	54	58
602	61	57	57	50	54	49	48	54
605	64	55	49	48	53	54	49	53
3197	60	46	54	55	48	56	44	52
398	58	55	56	48	52	42	46	51
Average	60	56	54	53	53	51	48	

A line	R line Yield of grain, bushels per acre, 1958								
	396	7078	3007-3	7000	5507	7005	5904	386	Average
378	90	89	91	84	85	82	80	66	83
3197	95	87	86	81	77	77	74	68	81
602	84	97	84	80	78	73	80	59	79
605	95	88	83	80	74	73	73	66	79
3047	91	78	86	82	67	73	75	71	78
398	92	78	84	84	74	73	66	65	77
399	87	82	79	76	74	75	72	70	77
Average	91	86	85	81	76	75	74	66	

A lines		R lines		
		R7078	Combine 7078	(Tx 7078)
A399	Resistant Wheatland	R396	Combine White feterita	(Tx 09)
A602	Combine kafir	R7000	Caprock	(Tx 7000)
A605	Combine kafir	R7005	Plainsman	(Tx 7005)
A3197	Combine kafir	R5507	Redbine selection	(Tx 07)
A398	Martin	R5904	R line	(Tx 04)
A378	Redlan	R5874	R line	(Tx 74)
A3047	Redbine selection	R3007-3	R line	
		R386	Redbine 60	(Tx 386)

The Forage Yield of Sorghum Hybrids

J. R. Quinby

By hybridization it is possible to produce some sorghum types that differ from grain sorghums, forage sorghums, or Sudangrass. Some intermediate types are already in production by commercial companies or by certified seed growers, but there is not much published information on the forage yield, grain yield and duration of growth of hybrids of the different types. A partial summary of yields from a forage variety test at Chillicothe in 1958 is shown in table 1.

The late maturing hybrids that result from complementary action of height and maturity genes are high in forage yield, extremely high in grain yield and very late in maturity. Combine kafir x Hegari derivative (A602 x R1306) is a hybrid of this type. An earlier maturing hybrid of similar type is (A385 x R6645).

Combine kafir x Sudan hybrids are intermediate in stem coarseness, are a little earlier than Sumac or Atlas, and are tall or not depending on the genetic height constitution of the Sudangrass parent. Piper hybrids are tall.

Hybrids between Combine kafirs and sorgo varieties are generally intermediate in height and maturity. Hybrids whose pollinators have kafir in their parentage (such as Atlas) are generally partially or almost completely sterile. Early maturing fertile hybrids of kafir x sorgo parentage yield about the same as sorgo varieties, but a greater proportion of the yield is grain.

It is yet to be determined whether or not there is a place for Kafir x Hegari hybrids as forage producers. Their value for silage and dry forage should be determined. The feeding value of the fine stemmed Sudangrass hybrids should also be determined as well as that of the male-sterile kafir x Atlas types.

Table 1. Forage yield of irrigated sorghum varieties at Chillicothe, Texas, 1958.

Hybrid or variety	Yield, cwt. per acre Air-dry forage	Grain	Days to 50% bloom	Height inches
FS[1], DeKalb	208	38	80	77
Combine kafir x Hegari derivative (A602 x R1306)	198	53	92	69
Sart	179	0	90	97
Honey	176	16	88	87
Kx 3065, Northrup-King hybrid	175	33	80	79
Sourless (African Millet)	154	36	79	87
Redlan x Piper Selection (A378 x R36259-1)	151	16	72	103
Combine kafir x Sweet Sudan sel. (A605 x R1950)	145	33	69	91
S 210, Frontier	141	25	71	76
Atlas	130	26	78	72
RS 303	129	37	66	81
Sumac 1712	128	23	79	68
RS 301	127	28	67	70
Combine kafir x Hegari derivative (A385 x R6645)	123	25	67	73
Hegari	122	20	74	47
RS 302	121	18	67	70
Sumac	114	28	75	74
Kx 3055, Early Forage Hybrid, Northrup-King	109	24	58	60

Efficiency of Lattice Designs in Sorghum Testing

N. W. Kramer and J. G. King (Lubbock)

Sorghum tests in Texas have been laid out in lattice designs for several years. For ordinary variety testing nothing can be lost from the use of lattice, but much can be gained in the way of efficiency at some locations.

The following figures present the gains in efficiency from 39 triple rectangular lattice tests, each with three replications, conducted in 1957 and 1958. The average gain in efficiency from the triple rectangular

lattice design used, relative to a randomized complete block design, was 34.4 percent. Gains ranged from nothing to 197 percent. The following table presents the frequencies of various gain percentages by classes:

Gain	No. of tests
No gain	9
1-10%	11
11-25%	4
26-50%	5
51-75%	5
76-100%	1
101-125%	1
126-150%	1
151-175%	0
176-200%	2

A Genetic Character for Stiff Stalk

R. E. Karper and N. W. Kramer (Lubbock)

Mwanga, a plant introduction received in 1950 via Otto Coleman, has proved to be an important source of germ plasm for improving stiffness of stalk in sorghum. It was introduced in 1946 as PEI 155762 in the collection of C. O. Grassl; it was collected 12 miles north of Blantyre, Nyasaland. The original collection was made for resistance to leaf anthracnose and other diseases.

At Lubbock Mwanga is an annual grass sorghum with small grassy seeds that shatter completely at maturity. The slender stalk is very hard and stiff due to a hard, thick cortex.

Mwanga was crossed with combine grain sorghums in 1951. In F_2 populations grown in the field in 1952 it was observed that seed shattering was almost completely linked with the hard cortex character. Additional crosses and backcrosses to combine sorghums have produced combine grain sorghum strains that have the stiff stalk character.

From counts in F_2 populations, it appears that the hard cortex character is governed by one gene with incomplete dominance. Populations of crosses of hard cortex x normal strains segregate approximately 1 stiff stalk: 2 moderately stiff: 1 normal.

Sorghum Head Smut

N. W. Kramer and J. G. King

Sorghum head smut, *Sphacelotheca reiliana*, has caused serious losses of yield in some grain fields in the Coastal Bend of Texas each year since 1954. The incidence of head smut has increased markedly since 1954, probably because an increasing proportion of the sorghum acreage has been planted to some of the more susceptible varieties and hybrids. In 1957 and 1958 serious economic losses from head smut were common, with some field infections running as high as 40 percent.

Head smut has been known in the United States since 1890. At various times it has been a problem in parts of the Sorghum Belt, but it has never before been as serious a problem as it is now in the Coastal Bend. Because of the extent and persistence of the infection at present in the Coastal Bend there is a possibility that a new race of the causal organism may have evolved, although there is no proof yet that the current epidemic is the result of a new race.

Head smut is caused by a soil-borne organism; the disease organism germinates in the soil and infects the young plants, so sorghum grown from disease-free seed in infected soil may be attacked. The spores are spread by wind when the mature smut galls on infected plants burst, so neither crop rotation nor sanitation measures is a very effective method of controlling infection. Because the infection occurs from the organism in the soil, seed treatment is not effective in controlling the disease, although all seed should still be treated for the control of other diseases. The only practical control for head smut appears to be the use of tolerant or resistant hybrids and varieties.

The amount of head smut infection on different varieties and hybrids has been studied in six field tests in the Coastal Bend in 1957 and 1958. The results of those studies and of one greenhouse experiment are presented in the following table:

Hybrid or variety	Head smut infection %
Combine 7078	24.7
Combine Shallu	23.3
RS 610	14.4
RS 608	14.4
AMAK R-10	14.4
AMAK R-12	13.8

Hybrid or variety	Head smut infection
	%
DeKalb F62a	10.5
DeKalb C44a	9.7
DeKalb E56a	9.6
Redbine-60	9.3
Texioca-54	8.0
RS 590	7.9
Texas 611	7.6
Texas 660	5.8
Martin	5.1
Redbine-58	5.0
Texas 601	4.8
Texas 620	3.8
RS 650	3.8
Redbine-66	1.7

Where head smut might be expected to be a serious problem, it is recommended that farmers avoid the use of highly susceptible varieties and hybrids such as Combine 7078, Combine Shallu, RS 610, RS 608, AMAK R-10, and AMAK-12. The use of rather susceptible varieties and hybrids such as F62a, C44a, E56a, Redbine-60, Texioca-54, RS 590, and Texas 611 under such conditions is questionable because losses can be quite heavy in this group when conditions are favorable for severe infections. The growing of adapted hybrids with a higher degree of tolerance to head smut is highly recommended.

Review of Sorghum Insects, Texas, 1958

J. G. King and N. W. Kramer

1958 was considered the worst year for sorghum insects infestation since the crop was first introduced in Texas. The build up of certain insects such as the sugarcane rootstalk borer and false chinchbug has been alarming in certain areas. This is probably the result of concentration of sorghum acreage. It is difficult to make an estimate of actual damage caused by insects on the crop, but it was considerable. The insects which are of economic importance are as follows.

The corn earworm or cotton bollworm is found in all sections of the state with a particularly heavy infestation occurring on the High Plains. At Lubbock the breeding nursery contained an average of two per head. The less compact heads appeared to have fewer larvae; however, damage was just as severe as in the tighter heads. This probably suggests that the use of

open head hybrids will not reduce, materially, damage from this insect. The only advantage the less compact head would have is easier application of insecticides. In trying to rate strains as to degree of earworm infestation, little progress was made.

The sugarcane borer is always a problem in the southeastern part of the state. Any increase in sorghum acreage in that section would also increase the borer population. Added to the problem is the appearance of the European corn borer in that section. Since both insects attack the plant in a similar manner, the outlook for sorghum acreage in this section will not increase until some resistance is incorporated into present lines. European corn borers have as many as three generations a year according to reports from Auburn. There is little reason to expect fewer numbers of generations in this state.

The sugarcane rootstock borer (Anacentrinus deplanatus) is potentially a very serious pest. At present serious infestation is localized in the McGregor-Waco area. It was first noticed on the Blue Bonnet Experiment Station at McGregor 3 years ago. Severe outbreaks have occurred on this station the last 2 years. It is hard to determine whether the insect causes the damage or if the damage results from the effect of charcoal rot which is always associated with infestations. The borer enters the plant and then completes the adult stage within the stalk. The point of penetration either allows the charcoal rot organism to enter or it is brought in by the larvae. Since charcoal rot develops in the plant under what is considered poor conditions for development of the fungus, some workers believe that the organism excretions activate the fungus. Under a heavy infestation a light wind is enough to cause 100% lodging. Sorghum strains with thick cortex will be grown in the area in 1959 to check for possible source of resistance.

Sorghum midge and webworm developed from the Rio Grande Valley to College Station and north to the Oklahoma border. Little can be done regarding these 2 insects unless resistance can be produced. Early planting dates help to control midge. It must be remembered that midge has been the determining factor in sorghum acreage for the central Texas area.

False chinch bugs, Nysius rephamus, have appeared in increasing numbers on the High Plains. This insect attacks the early planted fields, and the expected population is regulated by early season moisture. At present little concern is expressed about the insect except by farmers.

Southwestern corn borer was found in sorghum this year. From field observation it would appear that kafir might be the most susceptible variety.

Red spider mite is generally found all over the state. Hegari appears to be highly susceptible to this insect.

Effects of Defoliation on Sorghum

H. C. Lane (Lubbock)

The structure of the sorghum plant is much like that of corn. Sorghums have a single leaf at each node, a latent bud at most nodes, and buds at the crown. The growth of a bud on the stem results in a side-branch. Buds from the crown force into suckers. All shoots of sorghums terminate in an inflorescence commonly called a head.

Sorghums produce 10 to 16 leaves. Unlike cotton or soybeans, a sorghum plant will not initiate and grow new leaves if the original ones are destroyed. At Lubbock sorghum plants (var. Texas 660) were defoliated each week throughout the life cycle. The dates, growth stages, and results are shown in table 1. The crop was planted June 18. All exposed leaves were debladed at the collar between blade and sheath. The rolled leaves were cut off at the top of the roll.

Table 1. Results of defoliating sorghum plants.

Date	Height	Stage of growth	Number of leaves Full	Rolled	Grain yield % of undamaged
7-11	5- 6"	growing point at ground line	3	2	110
7-18	9-10"	" "	4	3	95
7-25	24-26"	3-4" above g.l.	6	3	72
8-1	30-32"	8-10" " "	8	2	10*
8-8	36-38"	30-32" boot stage	10	0	10*
8-15	40-42"	Early bloom	10+flag	-	16
8-22	44-48"	Full bloom	" "	-	14
8-29	48"	Early milk	8+1	-	25
9-5	48"	Full milk	7+1	-	60
9-12	48"	Early dough	6+1	-	62
9-19	48"	Mid-dough	6+1	-	75
9-26	48"	Hard dough	6+1	-	98
Check					100

*All sucker crop.

Removal of all leaves had its greatest effect on the original plant during the phase of rapid elongation of internodes, or just prior to and including the boot stage. In every case, the original plant was killed by the treatments at this stage of growth. The plants treated on August 1 did regrow by side branches. Those treated on August 8 died to the ground so quickly that true suckers were all that regrew. Removal of all leaves

before or after these two stages did not kill the plants, but no new leaves were produced. The greatest effect on the head and grain resulted from defoliation during the flowering stages. Ovules failed to grow normally after the treatment. Lodging of the plants tended to increase as a result of defoliation from early bloom to milk stage of the grain.

The results probably have immediate application to such problems as estimating hail damage to sorghum crops. But there are some other rather important questions raised. What conditions or causes, for example, exist in the plant during booting that made it so sensitive? It also seems obvious that this stage would be one of the more critical ones during the growth of the crop, and that faulty management during this stage would be most harmful to final yield.

Sorghum Adaptation Studies

K. B. Porter (Bushland)

Sorghum adaptation studies include yield tests of commercial and experimental hybrids on dry and irrigated land. The regional uniform hybrid nursery is grown as well as a number of State tests which include the most promising experimental hybrids developed in Texas.

Sorghum Row Spacing, Fertility Level, and Planting Rate Study

K. B. Porter, M. E. Jensen, and W. H. Sletten (Bushland)

This study has been conducted on irrigated land during the last three seasons. The variables included 12, 20, 30 and 40-inch row spacings planted at 4, 8 and 12 pounds per acre on two soil fertility levels. Significantly higher yields have been obtained with the 12 and 20-inch row spacings on the high fertility level. Planting rate had no significant influence on yield. Results of this study will be published in 1959.

Fertilizer Studies

Alex Pope (Bushland)

Soil fertility studies involving rates and ratios of different fertilizer materials have been conducted on irrigated grain sorghum in this area with the following results.

1. Irrigated sorghum on the hardlands responded to additions of nitrogen fertilizer, but the available phosphorus supply in these soils appears to be adequate at the present time.

2. Irrigated sorghum on sandy land required both nitrogen and phosphate fertilizer for optimum yield.

3. The rate of nitrogen fertilizer resulting in the greatest return per acre from fertilizer depended on the past cropping and fertilizer history as well as cultural and irrigation practices during the cropping year.

4. An adequate supply of soil moisture, particularly during the critical stages of growth, is necessary for efficient fertilizer use. Moisture stress is responsible for much of the lodging in sorghum.

In studies involving sources and rates of nitrogen on irrigated sorghum, no differences in yield were obtained among plots receiving five different sources of nitrogen at comparable rates of actual nitrogen.

Results of tests conducted to determine the effect of time of application of nitrogen fertilizer on the yield of irrigated grain sorghum on hardlands indicated preplant applications were as efficient as split applications or sidedressing applications. On the sandier soils however, split applications or sidedressing applications appear to be more efficient than where all of the nitrogen is applied prior to seeding. This is due in part to the fact that some of the nitrogen in heavy preplant applications is leached through the soil profile by subsequent irrigations.

Dryland sorghum on the hardlands does not normally respond to fertilizer while that on the sandier soils will respond only when a sufficient amount of moisture is available to carry the crop to maturity.

Insect Control

N. E. Daniels (Bushland)

A destructive infestation of a species of the false chinch bug group, *Nysius raphanus* (Howard), occurred on grain sorghum in several parts of the Panhandle during 1957-58.

Five insecticides - malathion, parathion, toxaphene, phosdrin and dieldrin were tested near Vega during the summer of 1958 for the control of the pest. Of the five tested, malathion and parathion gave satisfactory control.

Weed Control in Sorghum

A. F. Wiese (Bushland)

Studies over the past two years have shown that a single cultivation is the most economical and successful method of weed control in irrigated sorghum planted in 20 to 40 inch rows. One or two harrow operations or rotary hoeing are most successful for row spacings less than 20 inches.

If cultivation is not feasible, one-half pound of 2,4-D per acre may be applied at any stage except flowering without causing yield reductions. Applications of 2,4-D to sorghum less than three inches tall may inhibit root development and cause lodging.

Pre-emergence applications of chemicals have not been satisfactory. If weeds are controlled, sorghum is usually injured. A new chemical, propazine, tested in 1958 appears to be more satisfactory than other materials used previously.

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